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Automatic couplings on light railways,

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Figs. I to IV, pp. 944 to 947.

During the enquiry we made for the preparation of our report relating to question XX (Safety appliances on light railways) in the programme of the ninth Railway Congress (Rome 1922) (1), our attention was not drawn to any special system of automatic couplings for carriages and wagons.

Since writing and forwarding our report, we have had an opportunity of closely examining an apparatus of this kind which appeared to be particularly interesting and which we have put to practical tests.

This apparatus called the « Auto coupler + GF + » is made by the Schafhausen Steel Company, Limited, and is in use on several local lines in Switzerland.

The question of automatic coupling has been the subject of a number of articles in the *Railway Congress Bulletin*, and a fairly complete historical account of it was given by Mr. A. Campiglio in the June 1913 number.

Some of the most interesting systems have also been described and commented upon in the Bulletin, but generally in connection with lines dealing with large traffic.

However, most of the qualifications which are considered necessary in the application of automatic coupling systems, as notably for instance those given in the Ministerial Decree of 10 May 1912 relating to the open competition organised by the French Government for inventors of systems of automatic coupling of railway wagons (2), evidently also include their application to light railways.

It is therefore because the « Auto coupler + GF + » seemed to us to almost completely satisfy the conditions laid down as regards this class of railway that we have thought it of interest to write this article.

This system is essentially applicable to couplings with central buffers such as are adopted by these lines on account of their narrow gauge and the sharp curves which are so frequently met on them.

(1) See *Bulletin of the International Railway Association*, October 1921 number, p. 1539.

(2) See the *Railway Congress Bulletin* July 1912 number, p. 817.

It should be noted first of all that in the auto coupler in question there is no weak part, and no spring or gearing, that it is of great simplicity containing at the same time all that is necessary for buffering and coupling : it is made up in fact of only four parts, buffer included, all cheaply made and inexpensive to fit up.

It follows therefore that it is hardly more costly than any ordinary coupling, or at least there is very little in it.

The four parts are as follows :

1° The buffer which forms the coupling head.

This buffer is shaped like a funnel in which a slot is drilled at the bottom. Cast on to it is an arm C of flattened form which projects sufficiently to enable it to fit into the slot of the coupling head of the wagon to be coupled up to in such a way that its extremity, which is drilled for this purpose with a hole, may receive in the latter the spindle — or bolt — of this other head which will cause the coupling up to be accomplished;

2° A horizontal shaft F carrying at each of its extremities a small lever arranged so as to be worked by hand from either side of the wagon;

3° The spindle or bolt *d*, the vertical motion of which is controlled by a lever *e* keyed on the shaft F;

4° The pawl *g* which is hung on the same lever *e* and weighted at its bottom part.

The coupling heads are fixed to spring coupling bars which allow a lateral motion to take place in a slide.

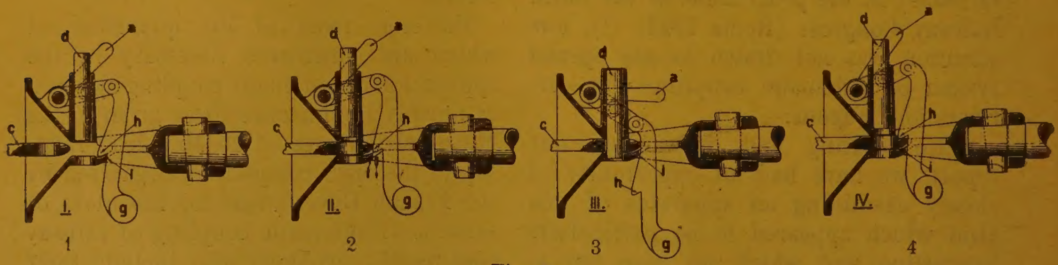

Fig. ¹.

Figure I_1 shows position before coupling up.

The arm *c* is ready to penetrate the slot in the coupling head of the wagon to be coupled up to, the hand levers of shaft F have raised the bolt that is kept in this position by the pawl *g* which, being raised at the same time as the bolt, rests by means of a spur on the surface *i*.

Figure I_2 shows arm *c* nearly at the bottom of its stroke and already beginning to force the pawl *g* to leave its position of rest on surface *i*.

In figure I_3 the action is finished, the pawl has fallen bringing the bolt into the hole in arm *c*, and the coupling is made.

In figure I_4, by means of the raising of the hand levers, the pawl has returned to its support on surface *i*, the bolt is withdrawn and all is ready for separating the wagons.

1. — It will be seen that the lowering of the bolt happens only when the buffers come into contact, and as soon as this occurs, the coupling of the wagons always

takes place immediately, the force required for liberating the pawl being practically nil.

On the other hand, we noticed that even with very rough shunting operations the coupling up was always perfectly accomplished and at sudden stops the open apparatus did not close.

2. — An uncoupling that is not desired can evidently only happen in case the apparatus breaks.

3. — The weight of the coupling head is hardly more than that of an ordinary coupling.

Figure II shows an automatic coupling fitted to a carriage.

Of course when the system is applied to tramway carriages, the parts will be generally lighter and the strength of the apparatus can be varied according to the tractive efforts to be dealt with.

4. — This coupling requires no special attention on the part of the employees, and can be worked without difficulty, special effort or danger, from either side of the vehicles. It should be pointed out in addition that the train staff is always sufficient for dealing with it, an important consideration for light railways where it is essential to reduce the staff to an absolute minimum.

5. — The shape given to the funnel allows the coupling to be effected when there is the maximum variation of height owing to wear of the tyres and with loaded wagons as well as with empty ones.

6. — The buffers being practically always close up, starting is easy and without shock. The running of the vehicles is consequently very steady.

7. — The only wear to consider is that of the bolt or the eye hole in the arm *c* which are consequently made in case hardened steel. This wear is small and in any case can be seen by simple inspection and can never give rise to danger.

It is desirable that the eye in the arm be made of harder metal than that of the bolt, so that the latter is the part requiring replacement, which is very quickly done.

In any case, danger from uncoupling through wear is not likely to occur.

8. — The effect of rough weather or of differences of temperature is not appreciable.

9. — The system has no safety coupling arrangement, which does not appear to be a necessity on light railways, the trains in general being relatively light.

10. — On account of the dimensions and shape of the funnel, coupling is accomplished without difficulty on curves of average dimensions.

On sharp curves, it is necessary to alter the position of the coupling heads either with the foot or by hand towards the centre of the track. In order to avoid, however, even this, a special arrangement is now employed, shewn in figure III, where the auto coupler is connected by crossed rods to the buffing springs.

With this arrangement, when two wagons to be coupled together meet on a curve, the parts of the coupling heads nearest the centre of the curved track coming together first, the rods on this side receive the first blow and pull the heads towards the centre, thus placing them in the requisite position for coupling up.

In cases of vehicles on bogies, the coupling arrangement is fixed on the latter and sets itself in accordance with the centre line of the road.

11. — It should also be noted that this system does not interfere in the least with

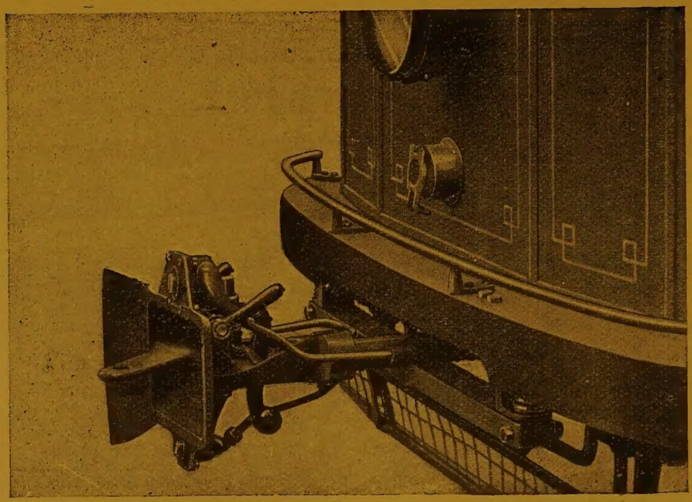

Fig. II.

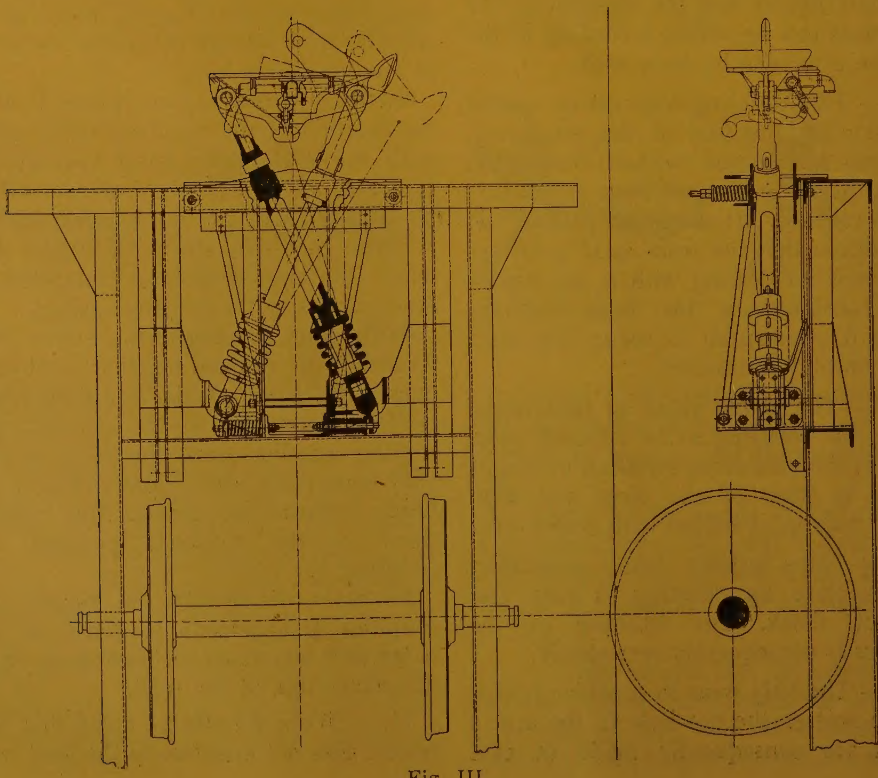

Fig. III.

the intercommunication between the carriages.

12. — Finally, the coupling can be suitably arranged in conjunction with the air pipes of the continuous brake, heating and lighting connections, etc.

It is in fact only necessary to fit special valves or couplings on the buffers, as the practically perfect and permanent contact between the buffers allows of suitable connections being made between these.

In this respect again a great economy in time and avoidance of all danger is obtained.

Figure IV shows one of these arrangements.

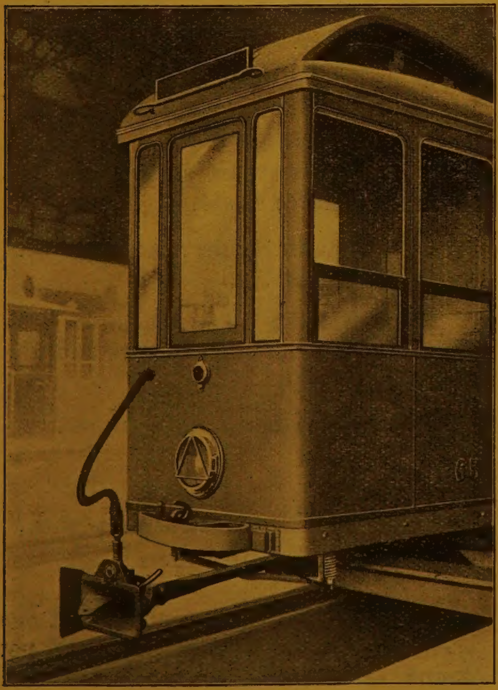

Fig. IV.

13. — It will be understood that the life of hose pipes and flexible cables, which in this system are not subjected to any movement, is considerably prolonged, which also is the case with the couplings themselves which are under ordinary circumstances liable to accidental damage and are costly to repair.

Whilst on this subject, we may refer to the visible signals which have been in use for some time on the electric trams of the town of Zurich and which allow by the use of lamps and a very simple code of signalling which transmits to the driver of the train all the indications necessary for working and safety, these being placed in the inside or outside of each one of the vehicles.

All audible signals which, in addition to being disagreeable to the public, cause confusion that is often dangerous, have been abolished.

The necessary intercommunication is also provided for automatically by the « Auto coupler + GF + » adopted on these tramways.

This system may evidently also be applied on local lines worked by electricity.

* * *

Mixed coupling, that is to say, a vehicle fitted with an ordinary coupling attached to one fitted with the « Auto coupler + GF + » must be specially arranged for in each case : on certain Swiss lines it has been possible to do it quite simply.

* * *

The « Auto coupler + GF + » is in use on seven local lines and on nine tramway lines in Switzerland, also on some foreign lines, and the information on the subject supplied to us by the Swiss authorities is most favourable.

[624. (01]

Plans of types of metallic superstructures for rail-bridges,

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Figs. 1 to 8, pp. 955 to 957.

At the conclusion of the Armistice a large part of our railway system had been destroyed. The greater part of the constructive works had been demolished, including a very large number of metallic superstructures.

During the occupation of Belgium the enemy burned or scattered the greater part of the documents belonging to the public services, not excluding those of the State Railways. We were therefore deprived of access to pre-war records for use in our task of reconstruction.

Further, some of the metallic superstructures which had been destroyed had become out-of-date. They had been designed for a much lighter type of train than those now in use. In short, it was necessary to draw up new plans for the replacement of the destroyed metallic superstructures. This work was entrusted to us by the Ways and Works Department of the Administration of the State Railways. The problem required a speedy solution.

It was not possible to adopt the old system of drawing up a separate plan for each metallic superstructure to be rebuilt. This would have been too lengthy and too costly a process. We thought it best to study a limited number of types of superstructure, and we made our choice to suit present-day conditions.

We first studied straight constructions. They are suitable for such bridges. Moreover, many skew bridges can take normal superstructures if the span is somewhat increased.

This method of procedure made it possible to secure a rapid solution of the problem.

The principles of economy were observed, for we were thus able, in many cases, to adopt construction in mass.

The plans of types studied may be divided into three classes :

I. — Metallic superstructures with under-rail girders.

II. — Metallic superstructures with track below (with solid girders and girder balustrades).

III. — Watertight metallic superstructures.

I. — Metallic superstructures with under-rail girders.

The span increases by intervals of one metre. For the present we have not found it necessary to make the span exceed 13 m. (42 ft. 8 in.).

Their use requires the availability of considerable height.

II. — Metallic superstructures with track below.

The span increases by intervals of one metre at first, and then by 2 m. and 2 1/2 m. (6 ft. 6 3/4 in. and 8 ft. 2 1/2 in.) intervals. This series included the study of some straight and some skew bridges with lattice-girder balustrades, of greater span, and of several superstructures for double track.

With superstructures of classes I and II may be used a type of balustrade with panels a metre (3 ft. 3 3/8 in.) long.

III.
Watertight metallic superstructures.

The span increases by intervals of one metre (3 ft. 3 3/8 in.). These constructions are necessary in important agglomerations.

A more complex type of balustrade, with panels a metre long, was studied in connection with these watertight superstructures.

The characteristics of these metallic superstructures are set out in the following tables.

N. B. — In the determination of H, relative to metallic superstructures, the basis taken has been a height of 15 cm. (6 inches) for the wooden sleeper, and 136 mm. (5 3/8 inches) for the rail of 40 kgr. 650 (81.945 lb. per yard) placed on support plate.

H, represents the distance between the lower level of the last plate and the upper level of the rail.

TABLE I. — **Superstructures with solid under-rail girders.**

Span.	Opening.	Total length of girder.	Number of plan.	H	E Half six-foot way, minimum.	Supporting structure.	
						Length.	Width
			A. — *Straight.*				
2.000	1.400	2.300	II $\frac{S}{n}$	0.590	1.000	0.300	0.230
3.000	2.350	3.350	III $\frac{S}{n}$	0.666	1.000	0.350	0.230
4.000	3.300	4.400	IV $\frac{S}{n}$	0.761	1.000	0 400	0.270
5.000	4.250	5.450	V $\frac{S}{n}$	0.836	1.000	0.450	0.290
6.000	5.100	6.500	VI $\frac{S}{n}$	0.836	1.000	0.500	0.400
7.000	6.100	7.500	VII $\frac{S}{n}$	0.936	1.000	0.500	0.400
8.000	7.100	8.500	VIII $\frac{S}{n}$	1.036	1.000	0.500	0.400
9.000	8.100	9.500	IX $\frac{S}{n}$	1.108	1.000	0.500	0.400
10.000	9.100	10.500	X $\frac{S}{n}$	1.132	1.000	0.500	0.400
11.000	10.100	11.500	XI $\frac{S}{n}$	1.258	1.000	0.500	0.400
12.000	11.100	12.500	XII $\frac{S}{n}$	1.282	1.000	0.500	0.400
13.000	12.100	13.500	XIII $\frac{S}{n}$	1.382	1.000	0.500	0.400

TABLE II. — Superstructures with track below with solid girders

Span.	Opening.	Total length of girder.	Number of plan.	H	P Span of tie-beams or distance between principal girders.	E Half six-foot way, minimum.	Supporting structure.	
							Length.	Width.
				A. — Straight.				
7.000	6.100	7.500	VII $\frac{I'}{n}$	0.680	2.650	1.000	0.500	0.400
8.000	7.100	8.500	VIII $\frac{I'}{n}$	0.692	2.650	1.000	0.500	0.400
9.000	8.100	9.500	IX $\frac{I'}{n}$	0.704	2.650	1.000	0.500	0.400
10.000	9.100	10.500	X $\frac{I'}{n}$	0.716	2.650	1.000	0.500	0.400
11.000	10.100	11.500	XI $\frac{I'}{n}$	0.775	2.900	1.000	0.500	0.400
12.000	11.100	12.500	XII $\frac{I'}{n}$	0.799	2.900	1.000	0.500	0.400
13.000	12.100	13.500	XIII $\frac{I'}{n}$	0.899	2.900	1.000	0.500	0.400
15.000	14.100	15.500	XV ^{I}	0.832	3.700	1.400	0.500	0.400

At the end of the war, the situation of the building shops and rolling mills was hardly more brilliant than that of our railway system. Many workshops had been completely destroyed, others had been stripped of their equipment, and few were in a position to recommence work immediately.

Further, workmen, and especially skilled workmen, were insufficient in number, while wages were rising continuously.

Also, the supply of coal was inadequate.

These difficult circumstances caused us, in studying metallic superstructures, to observe the following principles, which principles indeed are always important, but become still more so after so destructive a war as that through which we have just passed.

TABLE III. — **Superstructures for a track with lattice-girder balustrades.**

Span.	Opening.	Total length of girder.	Number of plan.	H	P Span of tie-beams or distance between principal girders.	E Half six-foot way. minimum	Supporting structure. Length.	Width.
			A. — *Straight.*					
17.500	16.400	18.100	XVII, $\frac{I}{50}$	0.838	4.800	1.975	0.600	0.450
20.000	18.900	20.600	XX ^{I}	0.850	4.800	1.975	0.600	0.450
22.500	21.400	23.100	XXII, $\frac{I}{50}$	0.874	4.900	2.025	0.600	0.450
24.399	23.099	24.999	On Scheldt at Eename.	0.832	4.900	2.025	0.600	0.450
27.500	26.200	28.100	XXVII, $\frac{I}{50}$	0.894	4.900	2.025	0.600	0.500
30.500	29.100	31.150	On Dendre at Deux-Acren.	0.882	4.900	2.025	0.650	0.500
39 330	38.100	40.030	On Scheldt at Peronnes.	0.898	5.000	2.175	0.700	0.600
44.550	43.100	45.300	On Scheldt at Chercq.	0.888	5.050	2.260	0.750	0.700
56.160	...	57.060	On Lys at Grammene.	1.130	5.200	2.315	0.900	0.800

Principles to be observed :

1° The construction of the metallic superstructures to be as simple as possible;

2° The number of different sections used to be reduced;

3° The use of excessively small sections to be avoided.

The object of the first two principles is to secure a more economical and efficient execution of the work. The third principle is intended to increase the durability of constructions.

For rail-bridges the plates should at least be 10 mm. (3/8 inch) thick. The smallest angle-irons to be used must be

$$\frac{80 \times 80}{10}.$$

Table IV. — **Superstructures for single-track with lattice-girder balustrades.**

Span.	Normal opening.	Angle and direction of inclination.	Total length of girder.	Number of plan.	H	P Span of tie-beams or distance between principal girders	E Half six-foot way, minimum.	Supporting structure.	
								Length.	Width
				B. — *Skew.*					
30.280	24.935	59°26'13" ⋋ Centre line of track.	30.930	On Scheldt at Leupeghem.	0.894	4.900	2.025	0.650	0.500
32.200	26 965	62°3' ⋋ Centre line of track.	32.850	On Dendre at Deux-Acren.	0.918	4.900	2.025	0.650	0.500
35.400	30.725	65°33'22" ⋋ Centre line of track.	36.150	On Dendre at Lessines-Carrieres.	0.906	4.950	2.100	0.750	0.550
33.630	28.000 approx.	60°51'41" ⋋ Centre line of track.	34.380	On Dendre at Deux-Acren.	1.082	5.950	—	0.800	0.550
20.600	18.000 approx.	⋌ 68°55'21" Centre line of track.	21.200	On Blaton to Ath Canal.	0.894	4.800	—	0.650	0.530
								recuperated.	

Table V. — **Superstructures for double-track with lattice-girder balustrades.**

Span.	Normal opening.	Total length of girder.	Number of plan.	H	P Span of tie-beams or distance between principal girders.	Supporting structure.	
						Length.	Width.
			A. — *Straight.*				
24.399	23.099	25.199	On Scheldt Pont des Boulages.	1.194	8.450	0.800	0.600
			B. — *Skew.*				
32.200	26.952	32.930	On Dendre at Deux-Acren.	1.406	8.600	0.900	0.750
33.630	28.000 approx.	34.550	On Dendre at Deux-Acren.	1.406	8.600	0.900	0.750
20.600	18.000 approx.	21.400	On Blaton to Ath Canal.	1.206	8.400	0.800	0.600

TABLE VI. — **Watertight superstructures with track below.**

Span.	Opening.	Total length of girder.	Number of plan.	H	P Span of tie-beams, or distance between principal girders.	E Half six-foot way, minimum.	Supporting structure.	
							Length.	Width.
A. — *Straight*								
8.000	7.100	8.500	VIII[E]	1.014	2.800	1.000	0.500	0.400
9.000	8.100	9.500	IX[E]	1.014	2.800	1.000	0.500	0.400
10.000	9.100	10.500	X[E]	1.026	2.800	1.000	0.500	0.400
11.000	10.100	11.500	XI[E]	1.038	2.800	1.000	0.500	0.400
12 000	11.100	12.500	XII[E]	1.038	2.800	1.000	0.500	0.400
13.000	12.100	13.500	XIII[E]	1.116	2.800	1.000	0.500	0.400

The construction of the metallic superstructures to be as simple as possible.

In our opinion a definite approximation to industrial frame-work must be sought, and even this must be simplified so as to be more constructive. With this object we have systematically excluded forged parts. They require, *in fact*, specialised workmanship and a considerable consumption of fuel. They are therefore very costly. Also, the metal of forged parts is impaired, and their construction is correspondingly less perfect.

It is true that, at first sight, this procedure appears to entail an extra quantity of metal, but very often this is not so in reality. Bars with lining are, for example, more resistant to corrosion, a great advantage, particularly in the case of uprights and certain diagonals of lattice-girders.

We also attempted to simplify the riveting considerably. This question is too often treated as of secondary importance.

We have drawn up all our plans for metallic superstructures for rail-bridges to include the use of a rivet of standard diameter. We are the first to adopt this simplification of construction, a real simplification, the advantage of which has been readily appreciated, for the making of the rivets is standardized; the chances of error in drilling are considerably diminished; suitable drills are easily procured; supervision is facilitated, etc.

A standard rivet diameter of 22 mm. (7/8 inch) can be adopted without inconvenience or difficulty if appropriate sections and plate-thicknesses are chosen.

Some particulars on this point will now be given :

Angle-irons :

The most suitable forms are the following :

$$\frac{80\times 80}{10},\quad \frac{90\times 90}{10},\quad \frac{120\times 120}{12}$$

$$\text{and } \frac{150\times 150}{12}.$$

Angle-irons of $\frac{80\times 80}{10}$ and $\frac{90\times 90}{10}$ have a row of rivets with about 10 cm. (3 15/16 inches) intervals.

Angle-irons of $\frac{120\times 120}{12}$ have two rows of rivets (20 mm. [25/32 inch] apart) with intervals of 18 cm. (7 1/16 inches); thus the distance between two adjacent rivets is about 90 mm. (3 9/16 inches). The clamping and tightening is perfect.

Angle-irons of $\frac{150\times 150}{12}$ also have two rows of rivets (50 mm. [2 inches] apart), but the interval is 15 cm. (6 inches) so as to give a similar riveting to that used with angle-irons of $\frac{120\times 120}{12}$.

Angle-irons of $\frac{100\times 100}{10}$ and $\frac{110\times 110}{10}$ do not give very satisfactory riveting. Their wings are too narrow to hold two rows of rivets and a single row gives imperfect tightening.

It is therefore advisable, as far as possible, to avoid the use of these two angle-irons.

Plates :

T — *shape section* :

200 mm. (7 7/8 inches) plates give good sections with angle-irons of $\frac{80\times 80}{10}$.

250 mm. (9 13/16 inches) plates give good sections with angle-irons of $\frac{90\times 90}{10}$.

300 and 350 mm. (11 13/16 and 13 13/16 inches) plates give good sections with angle-irons of $\frac{120\times 120}{12}$.

350 mm. (13 13/16 inches) plates give good sections with angle-irons

$$\text{of } \frac{150\times 150}{12}.$$

Box-shape section.

The following combinations are recommended :

1° Angle-irons of $\frac{80\times 80}{10}$ with 400 or 450 mm. (15 3/4 or 17 11/16 inches) plates and 300 and 350 mm. web (11 13/16 and 13 13/16 inches).

2° Angle-irons of $\frac{90\times 90}{10}$ with 450 and 500 mm. (17 11/16 and 19 11/16 inches) plates and 350 and 400 mm. web (13 13/16 and 15 3/4 inches);

3° Angle-irons of $\frac{120\times 120}{12}$ with 600 mm. (23 5/8 inches) plates and 600 mm. (23 5/8 inches) web.

We have given considerable attention to the sections of the component parts of metallic superstructures with the object of simplifying their construction; thus the junction-plates of the lattice-girders are in the form of convex rectilinear polygons.

The junction-plates of the tie-beams to the principal girders are all identical for any metallic superstructure, etc.

We have carefully considered a new bracing arrangement for the fixed supporting parts (see figs. 1 and 2).

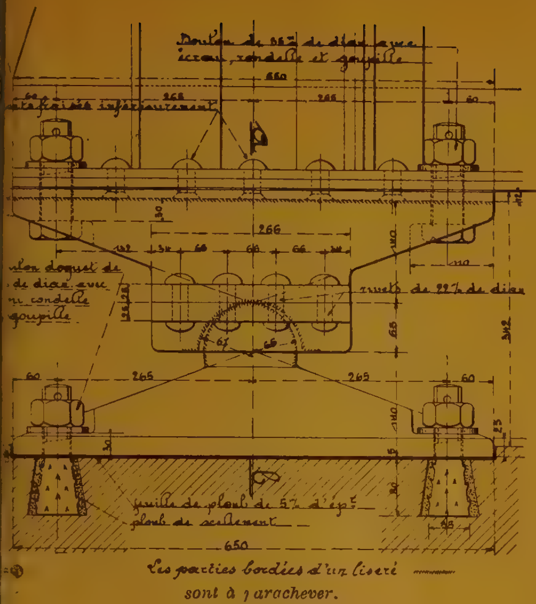
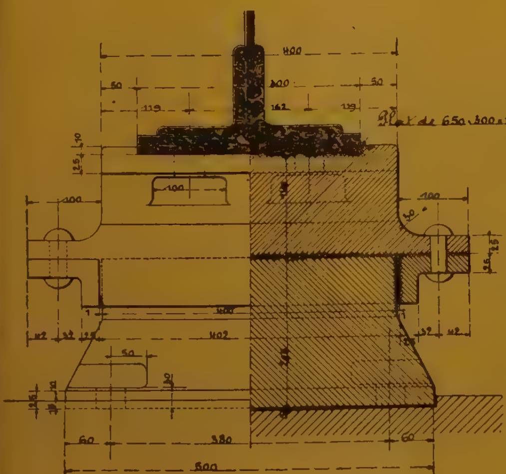


Fig. 1. — Elevation.

lanation of French terms : Boulon de 35 mm. de diam. avec crou, rondelle et goupille = 1 $^3/_8$ inch bolt with nut, washer and ey. — Rivets fraisés inférieurement = Rivets countersunk below. - Boulon doguet de 35 mm. de diam. avec écrou, rondelle et gouille = 1 $^3/_8$ inch bolt with nut, washer and key. — Rivets de 22 mm. e diam. = $^7/_8$ inch rivets. — Feuille de plomb de 5 mm. d'ép^r = heet lead $^3/_{16}$ inch thick. — Plomb de scellement = Fastening lead. - Les parties bordées d'un liseré ////////// sont à parachever = The rts edged thus ////////// must be worked out to true dimensions.



Half-view. Half-section *ab.*

Fig. 2.

Explanation of French terms : Plat de 650 × 300 × 12 = Plate 25 $^5/_8$ × 11 $^{13}/_{16}$ inches × $^{15}/_{32}$ inch.

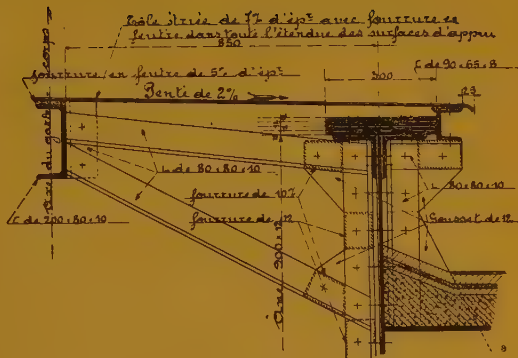


Fig. 3. — Transverse section of gangway.

Explanation of French terms : Tôle striée de 7 mm. d'ép^r avec fourrure en feutre dans toute l'étendue des surfaces d'appui = 7 mm. checkered plate with felt lining on entire support surface. — Axe du garde-corps = Centre line of balustrade. — Fourrure en feutre de 5 mm. d'ép^r = Felt lining $^3/_{16}$ inch thick. — Pente de 2 %. = Slope of 2 %. — Fourrure de 10 mm. = Lining $^3/_8$ inch thick. — Fourrure de 12 mm. = Lining $^{15}/_{32}$ inch thick. — Gousset de 12 mm. = $^{15}/_{32}$ inch junction-plate.

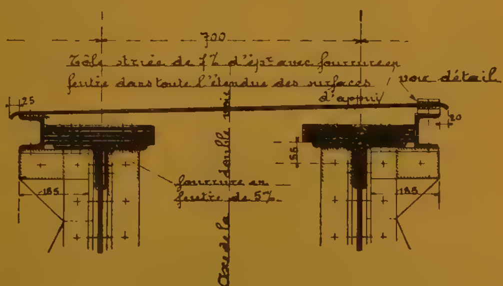


Fig. 4. — Cross-section of six-foot way.

Explanation of French terms : Tôle striée de 7 mm. d'ép^r avec fourrure en feutre dans toute l'étendue des surfaces d'appui = $^9/_{32}$ inch checkered plate with felt lining on entire support surface. — Voir détail = See detail. — Axe de la double voie = Centre line of double-track. Fourrure en feutre de 5 mm. = $^3/_{16}$ inch lining.

Figs. 5 to 8. — Diagrams showing weight of metallic superstructures in tons in relation to their span in metre
This tonnage covers : rolled steel, cast steel, lead, rivets, and bolts, and finally balustrades.

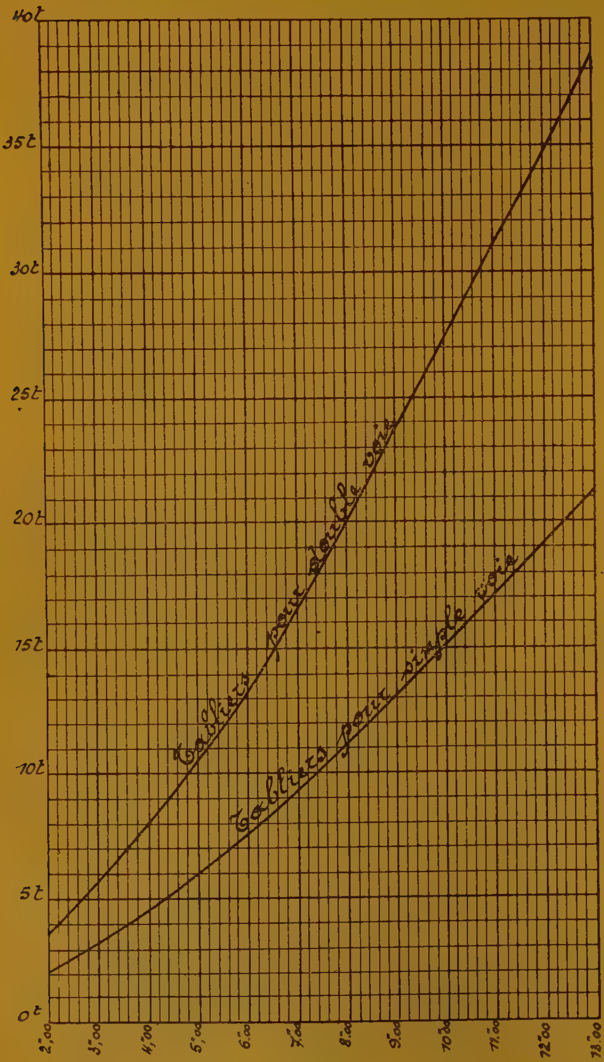


Fig. 5. — Superstructures with under-rail girders.

Explanation of French terms : Tabliers pour double voie = Superstructures for double-track. — Tabliers pour simple voie. — Superstructures for single-track.

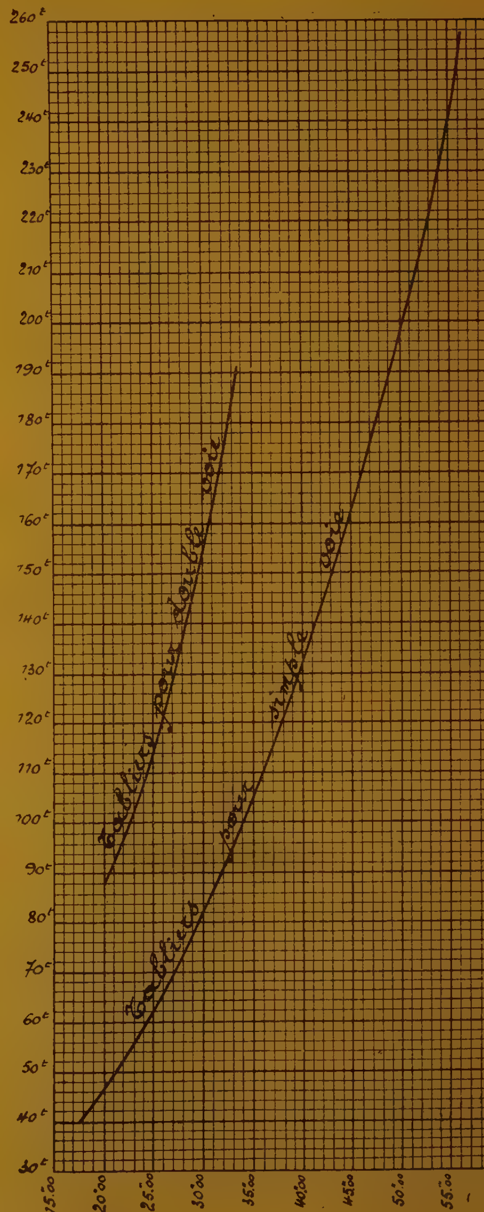


Fig. 6. — Superstructures with track below wi
lattice girders.

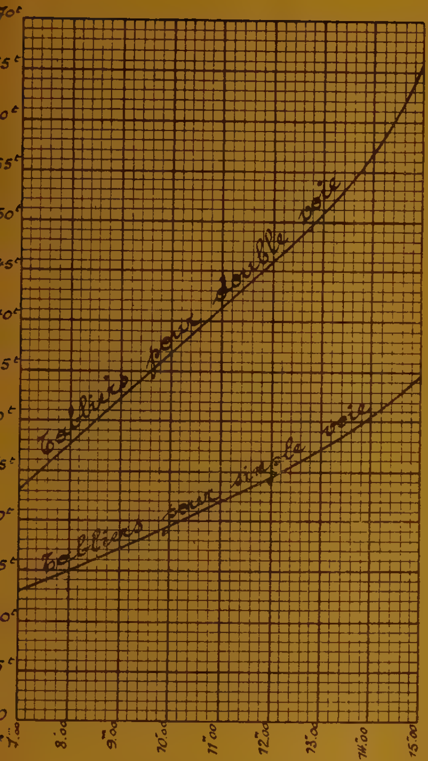


Fig. 7. — Superstructures with track below with solid girders.

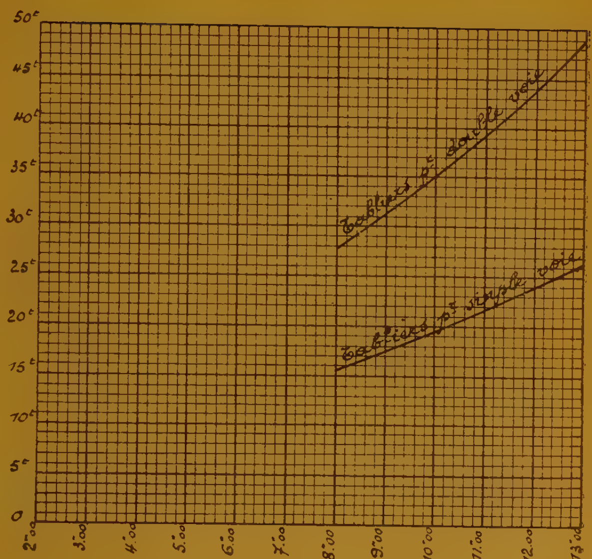


Fig. 8. — Watertight superstructures.

Explanation of French terms : Tabliers pour double voie = Superstructures for double-track. — Tabliers pour simple voie = Superstructures for single-track.

Our method of supporting the footways and the covering of the six-foot way in watertight superstructures is very simple, and has the great advantage of leaving the principal girder intact (see figs. 3 and 4).

These are a few instances in which simplicity of construction is secured, while at the same time taking into account data regarding stability.

The number of different sections used, to be reduced.

The number of different sections used is considerably reduced.

We employ four angle-irons :

$$\frac{80 \times 80}{10}, \quad \frac{90 \times 90}{10}, \quad \frac{120 \times 120}{12}$$

$$\text{et} \quad \frac{150 \times 150}{12}.$$

The sheets and large plates are 10 or 12 mm. (3/8 or 15/32 inch) thick.

Add to this some ⊔ irons, and you have all that is necessary in order to design present-day metallic superstructures.

There is everywhere noticeable a tendency towards standardisation, and notably towards the standardisation of sections.

We have then shown in a practical manner that standardisation is possible in the construction of rail-bridges, not only as regards sections, but also as regards rivets, and this in a greater measure than has hitherto been attempted.

The use of excessively small sections to be avoided.

It is scarcely necessary to enunciate this principle. Its importance is self-evident. We all know that the strengthening of existing constructions is exceedingly costly. This strengthening is to a great extent obviated if excessively small sections are excluded.

Further, the sections of the superstructure girders must be comparable. A very weak section joined to a very strong one is a faulty piece of construction. There must be continuity of construction.

It naturally follows, therefore, that sections which are too light must be avoided.

We have studied plans of various types in the hope of obtaining very simple and consequently very economic constructions. Our hopes have not been disappointed.

The quotations obtained were very favourable in the case of the thirty odd firms who tendered for various types of superstructures, the necessary allowance being made of course for the competitive element.

The attached diagrams (figs. 5 to 8) will illustrate the above remarks.

[625 .142.4]

Note on some recent types of reinforced concrete sleepers,

By Mr. R. DESPRETS,
PRINCIPAL ENGINEER OF THE BELGIAN STATE RAILWAYS.

Figs. 1 to 6, p. 960 to 969.

The investigation made below relates particularly to sleepers of the « *Calot* type » tried by the Paris-Orleans Railway Company and to sleepers of the « *Vagneux* type » tried by the Paris-Lyons-Mediterranean Railway Company.

These sleepers will be described in the paper and they appear to represent the most logical conclusion at the present time in our countries to the various attempts that have been made to construct durable sleepers of reinforced concrete.

1. — General considerations.

Two distinct tendencies are shown in the construction of reinforced concrete sleepers.

The one, based on the form and on the elastic properties of wooden sleepers, keeps closely to the construction of reinforced concrete sleepers of approximately prismatic form; the other reverts towards the system of separate rail supports connected by a stay sufficiently rigid to render them a single unit.

The first trials made on a large scale by the Italian State Railways were carried out on long sleepers of the first type; these sleepers which were 2.60 m. (8 ft. 6 3/8 in.) in length complied with the conditions met by wooden sleepers of giving equal deflection at the middle and at the ends of the sleeper when loaded.

This waved (sine-curve) form is characteristic of long wooden sleepers and ensures the maintenance of the rail in the best position, during the passage of the wheel over it, by strictly limiting the deviation of its cross section in the vertical plane.

On the other hand this length of sleeper is the least satisfactory for resisting the stresses under the rail.

As we shall show below, for a wooden sleeper 2.70 m. (8 ft. 10 3/8 in.) in length of half-round beech 28 × 14 cm. (11 × 5 1/2 in.) the bending moment immediately under the rail is double the bending moment at the centre of the sleeper.

It is not surprising therefore that the Italian reinforced concrete sleepers 2.60 m. (8 ft. 6 3/8 in.) long should have broken under the rails.

The latest trials on the Italian State Railways, like those made by the Orleans Railway, were made on sleepers 2.40 m. (7 ft. 10 1/2 in.) in length.

We shall show below in the analysis of the « *Calot* » type sleepers that this length is that which gives equal bending moments at the centre and immediately under the rails.

Finally the length of 2.40 m. (7 ft. 10 1/2 in.) will be that of equal strength for reinforced concrete sleepers of uniform section.

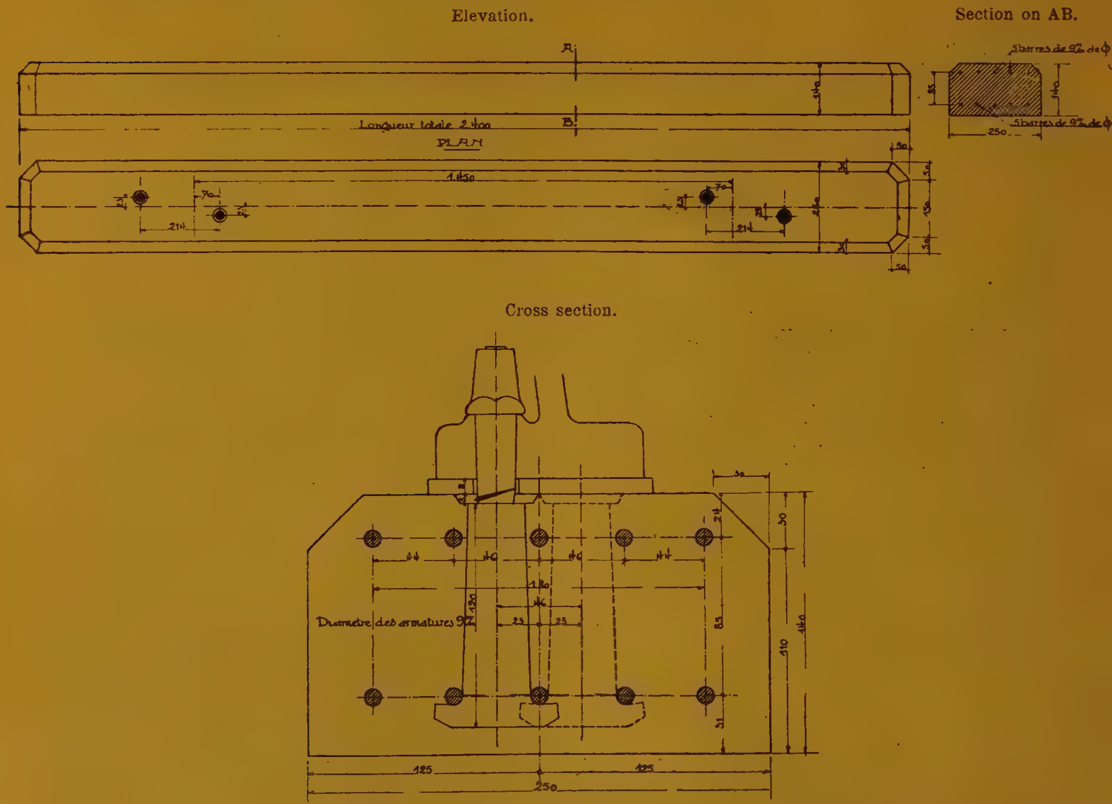


Fig. 1. — Orleans Railway. — Reinforced concrete sleeper with ordinary chairs.

Explanation of French terms : Longueur totale = Length over all. — 5 barres de 9 mm. de diam. = 5 bars each 11/32 inch diam. Diamètre des armatures 9 mm. = Diameter of reinforcing bars 11/32 inch.

We draw attention to the fact that there is a fundamental technical difference between wooden sleepers and reinforced concrete sleepers of uniform section.

The length of the first is determined by a condition which might be called that of equal deformation of the sleeper, whereas the length of those of the second class is determined by the condition which one might term that of equal strength.

These conditions follow from the hypothesis of a constant resistance of the ballast under the sleeper, which in fact implies uniform packing under the whole length of the sleeper.

This is not generally the case in practice on railways, at any rate at the commencement of maintenance work.

Special care should be given to packing the sleeper at the ends and under the rail.

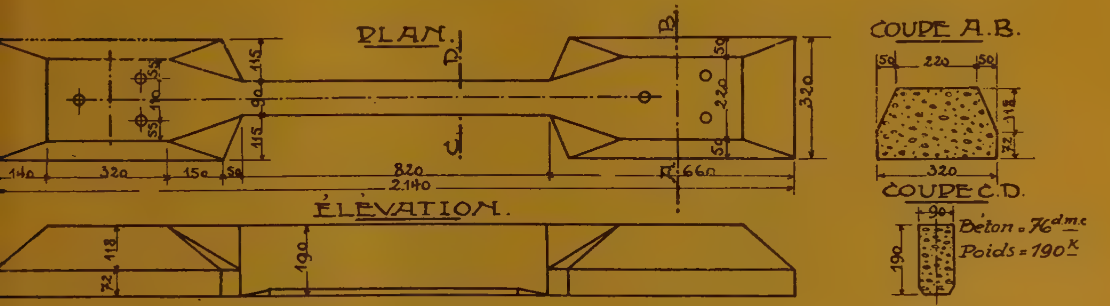
It must however be noted that, in course of time, owing to vibration, the packing ceases to be tight and the tendency is towards that of a constant resistance in the ballast.

It is interesting to note that the length of 2.40 m. (7 ft. 10 1/2 in.) of the « *Calot* » sleeper was settled by the inventor who based his calculation on the hypothesis of packing for 0.35 m. (1 ft. 1 3/4 in.) on each side of the rail, with a uniform unit pressure over the bearing surface.

The maintenance of the track by packing the ends of the sleepers has also been the deciding influence in the original idea for the second type of reinforced concrete sleepers of which the best existing example is the « *Vagneux* » sleeper tried by the Paris-Lyons-Mediterranean Company.

The « *Vagneux* » sleeper with a reinforced concrete or a metallic cross stay consists essentially of two large reinforced concrete blocks under the rails connected by a narrow girder of reinforced concrete or a metal cross-stay of I-section.

Sleeper with reinforced concrete cross-stay.



Sleeper with rolled-section cross-stay.

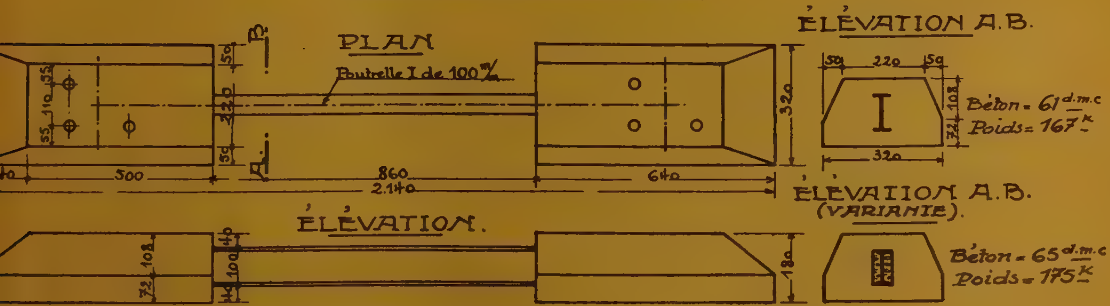


Fig. 2. — Vagneux patent system. — June 1921. — Standard type, model 2.

Explanation of French terms : Coupe A-B (C-D) = Section on A-B (C-D). — Béton = Concrete. — Poids = Weight. — Poutrelle I 100 m/m = I-joist 3.94 inch deep. — Élévation A-B = Elevation on A-B. — Élévation A-B (variante) = Elevation on A-B (alternative).

The bearing surface of the blocks is sufficient to ensure a proper distribution of the loads on the ballast; on the other hand in case of the ballast sinking equally

on both sides with consequent bearing of the cross-stay on the ballast, the reduced area of the cross-stay relieves it almost entirely from the bending forces due to the reaction of the ballast.

Moreover, as the packing is never perfectly even under the two blocks, the stay must be able, under normal conditions, to resist the stresses arising from the inequality of the deflections due to the vertical and horizontal forces acting on the rails.

2. — Investigation of a reinforced concrete sleeper.

Zimmermann's formulæ which served as the basis for calculations of the strength of sleepers are as follows :

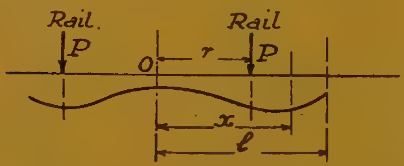


Fig. 3.

$$X = \sqrt[4]{\frac{Cb}{4EI}} \quad . \quad . \quad . \quad . \quad . \quad . \quad Xx = \xi$$

C, the coefficient of compressibility of the ballast.

b, the width of the sleeper . . . $Xr = \varsigma$

E, the coefficient of elasticity. . $Xl = \lambda$

I, the moment of inertia.

W, the vertical force exerted by the rail on the sleeper.

Deflection immediately under the rail :

$$Yr = \frac{XW}{Cb}(\mu\varsigma).$$

Bending moment in the sleeper at the centre of the rail :

$$M_r = \frac{W}{2X}[\mu\varsigma].$$

Winkler's hypothesis :

$$W = DYr$$

$$D = \frac{Cb}{X[\eta\varsigma]}.$$

Deflection at the ends of the sleeper :

$$Y_1 = \frac{XW}{Cb}[\eta\lambda].$$

Deflection at the centre of the sleeper :

$$Y_0 = \frac{XW}{Cb}[\eta_0].$$

Bending moment at the centre of the sleeper :

$$M_0 = \frac{W}{2X}[\mu_0].$$

These equations only hold on the assumption that the compressive coefficient of the ballast remains constant, that is to say that the packing is uniform for the whole length of the sleeper.

By means of these equations we shall compare the technical conditions for a beech sleeper 2.60 m. (8 ft. 10 3/8 in.) in length of half round section 28 × 14 cm. (11 × 5 1/2 inches) with those of a reinforced concrete sleeper of the « *Calot* » type 2.40 m. (7 ft. 10 1/2 in.) in length, of 25 × 14 cm. (9 13/16 × 5 1/2 inches) cross-section reinforced by two equal groups of longitudinal reinforcement of 5 bars, each 9 mm. (11/32 inch) in diameter.

« Calot » sleeper. — We will first calculate the values of X for the two coefficients of ballast C = 3 and C = 8.

Moment of inertia :

$$I = I_b + 10\, I_m$$

$$F_m = F'_m = 3\ \text{cm}^2.18 \text{ (five bars each 9 mm. in diameter).}$$

Vertical distance between reinforcing bars : 8.5 cm. (3 11/32 inches) :

$$I_m = 3.18 \times \overline{\frac{(8.5)}{2}}^2 = 115 \text{ cm}^4$$

$$I_b = \frac{BH^3}{12} = \frac{25 \times 14^3}{12} = 5\,700$$

$$I = 6\,850.$$

For C = 3 :

$$X_1 = \sqrt[4]{\frac{Cb}{4EI}}$$

$$= \sqrt[4]{\frac{3 \times 25}{4 \times 210\,000 \times 6\,850}} = 0.0107.$$

For C = 8 :

$$X_2 = 0.0136.$$

If the diameter of the reinforcing bars were increased from 9 to 12 mm. (11/32 to 15/32 in.) :

$$\Omega = \omega = 5 \text{ cm}^2.65, \quad I_m = 203,$$

$$I = 7\,730.$$

For C = 3 :

$$X_3 = 0.0104$$

For C = 8 :

$$X_4 = 0.0133.$$

These values of X show that for sleepers of the same length and of the same cross-section, *the diameter of the reinforcing bars will only have a small influence on the magnitude of the deflections and of the bending moments of the sleeper.*

In the case of the « *Calot* » sleeper assumed, the bars being 9 mm. (11/32 inch) in diameter :

$$X_1 = 0.0107$$

$$X_2 = 0.0136.$$

The length of the sleeper being 2.40 m., $l = 120$ and $r = 75$.

$$\varsigma = Xr$$

$$\lambda = Xl$$

for $X_1 = 0.0107$:

$$\varsigma_1 = 0.0107 \times 75 = 0.8$$

$$\lambda_1 = 0.0107 \times 120 = 1.28$$

for $X_2 = 0.0136$:

$$\varsigma_2 = 0.0136 \times 75 = 1.02$$

$$\lambda_2 = 0.0136 \times 120 = 1.63.$$

First case :

$$X_1 = 0.0107$$

$\eta_0 = 0.696$ $\eta\varsigma = 0.8165$ $\eta\lambda = 0.8771$

$\mu_0 = 0.2637$ $\mu\varsigma = 0.1976$

Second case :

$$X_2 = 0.0136$$

$\eta_0 = 0.4787$ $\eta\varsigma = 0.6774$ $\eta\lambda = 0.7433$

$\mu_0 = -0.2729$ $\mu\varsigma = 0.2678$

These values of η and μ enable us to deduce *certain conclusions :*

In the two cases the sleeper is bent as in the case of short sleepers, the curvature being always in the same direction; the deflection increases from the middle to the ends. The bent neutral axis is therefore convex upwards.

In the first case where X = 0.0107 and ς = 0.8, the value of λ = 1.44, that is to say $l = \frac{1.44}{0.0107}$ = 135, applying to a sleeper 2 m. 70 (8 ft. 10 3/8 in.) in length, gives equal deflections at the centre and ends.

The equality of the bending moments which is nearly realized when $l = 120$ is obtained when $l = 124.8$, that is to say for a length of sleeper of 2.50 m. (8 ft. 2 1/2 in.).

In the second case the equality of the bending moments at the centre of the sleeper and the centre of the rail is practically realized.

The equality of the deflections at the centre and ends will also be obtained when $\varsigma = 1$, $X = \frac{1}{75} = 0.0133$ for a length of sleeper where $\lambda = 1.8$, that is $l = \frac{1.8}{0.0133} = 135$, which gives a sleeper 2 m. 70 (8 ft 10 3/8 in.) in length.

For this length,

$$\mu_\varsigma = \frac{0.3492}{0.1814}\mu_0 = 1.92\,\mu_0.$$

The bending moment through the centre of the rail is almost double the bending moment at the centre of the sleeper.

We also find that whatever may be the nature of the ballast the value of μ_0 is sensibly equal to 0.27.

Beech sleeper of half-round section : If R is the radius of the half circle, $R = 14$, $I = 0.110\,R^4$, $E = 110\,000$ kgr. per cm².

For $C = 8$,

$$X = \sqrt[4]{\frac{8 \times 28}{4 \times 110\,000 \times 0.11 \times 14^4}}$$

$X = 0.0186$.
$\varsigma = X \times r = 0.0186 \times 75 = 1.39$.
$\lambda = X \times l = 0.0186 \times 130 = 2.42$.
$\eta_0 = 0.2830$. $\eta_\varsigma = 0.5188$. $\eta\lambda = 0.3351$.
$\mu_0 = -0.2209$. $\mu_\varsigma = 0.4413$.

This sleeper tends towards the equality of the deflections at the middle and ends. This equality occurs for a length of 2.70 m. (8 ft. 10 3/8 in.).

$$\eta_0 = 0.2837. \quad \eta\lambda = 0.2730.$$

On the other hand $\mu_0 = 0.2169$.

$$\mu_\varsigma = 0.4530 > 2\mu_0.$$

The bending moment through the centre of the rail is more than twice as great as the bending moment at the centre of the sleeper.

For $\varsigma = 1.4$, $\lambda = 2.04$ gives μ_0 and μ_ς equal in absolute value to 0.3. This equality of bending moments occurs for a sleeper of a length of 2 m. 20 (7 ft. 2 5/8 in.).

Respective influence of these two types of sleepers on a track laid with rails weighing 50 kgr. per m. (100.79 lb. per yard).

We will assume the span between centres of the sleepers in both cases to be 800 mm. (2 ft. 7 1/2 in.).

The I of the new rail of the Belgian State Railways weighing 50 kgr. per cm² = 1787.5 cm⁴.

$$D = \frac{Cb}{X[\eta_\varsigma]}, \qquad \Upsilon = \frac{6\epsilon}{DL^3}.$$

The various values of D and Υ are given in the table below :

TYPES.	C	X	D	Υ
Reinforced concrete sleeper 2 m. 40 (7 ft. 10 1/2 in.) long.	3	0.0107	8 600	4.85
	8	0.0136	21 700	1.92
Beech sleeper 2 m. 60 (8 ft. 6 3/8 in.) long.	3	0.0146	9 900	4.23
	8	0.0186	23 200	1.8

We have calculated the bending moments and the successive reactions of the rail in the two cases of an axle over the sleeper or of an axle over the middle of the span between sleepers, according to the method given in the *Bulletin of the International Railway Association* (DESPRETS, February 1921). These calculations being extremely long and complicated, we will confine ourselves to considering the main results for the values $\Upsilon = 1.92$ and $\Upsilon = 1.8$.

These results are given in the tables below :

Axle immediately over a sleeper.

γ	Bending moment on the rail immediately over the sleeper.	Reaction of the rail on the sleeper.
$\gamma = 1.8$ wood	-0.22 PL	0.47 P
$\gamma = 1.92$ concrete	-0.24 PL	0.47 P

Axle immediately over the centre of a span.

	Bending moment of the rail at the middle of the span.	Reaction of the rail at the ends of the span.
$\gamma = 1.8$ wood	$-0.571 \frac{PL}{2}$	0.40 P
$\gamma = 1.92$ concrete	$-0.579 \frac{PL}{2}$	0.396 P

We conclude that the maximum bending moments in the rail are slightly greater with a permanent way laid on concrete sleepers than with a permanent way on wooden sleepers.

The maximum reactions on the sleeper are approximately the same.

On the other hand, as $Y_r = \frac{W}{D}$ and D for wood > D for concrete, the sinking of reinforced concrete sleepers should be greater than the sinking of wooden sleepers.

Calculation of the elastic stresses in the « Calot » sleeper.

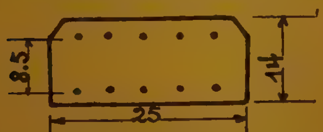


Fig. 4.

This sleeper of 14 × 25 cm. (5 1/2 × 10 in.) cross-section with two equal groups of longitudinal reinforcement, consisting each of five bars 9 mm. (11/32 inch) in diameter placed 8.5 cm. (3 11/32 inches) apart in height.

The neutral axis is determined by the following equation :

$$x = -\frac{n(\Omega + \omega)}{b} + \sqrt{\frac{n(\Omega + \omega)^2}{b} + \frac{2 \cdot n}{b}[\Omega(h - a) + \omega a']}$$

$\Omega = \omega = 3\ \text{cm}^2.18$ $\quad h = 14$

$n = 15$ $\quad a = a' = 2.75$

$b = 25.$

$$x = 4.4$$

The stresses are determined by the following equations :

Concrete :

$$Rb = \frac{2Mx}{bx^2\left(h - a - \frac{x}{3}\right) + 2n\omega(x - a')(h - a - a')}$$

Steel :

$$Rm = nR_b \times \frac{h - a - x}{x}$$

$$Rb = \frac{8.8}{5\,960} M$$

$$Rm = 15 \times \frac{6.8}{4.4} \sigma b$$

The maximum bending moment M is the moment which we have previously designated M_0; $M_0 = \frac{W}{2X}[\mu_0]$.

For C = 8, $\gamma = 1.92$, the maximum load W of the wheel on the sleeper = 0.47 × the load on the wheel.

In the type 10 locomotives, the maximum load on an axle is 19 tons; under these conditions W = 0.47 × 9.5 tons = 4.46 tons.

$$M_0 = \frac{W}{2X}[\mu_0] = -W \times \frac{0.2729}{2 \times 0.0136} =$$

$$-10W \text{ approximately.}$$

$$M_0 = -44\,600 \text{ kgr.} \times \text{cm.}$$

This value of M gives the values below for the elastic stresses in the concrete and in the reinforcement :

$Rb = 66$ kgr. per cm².
$Rm = 15$ kgr. 3 per mm².

If the concrete is not taken into account and the reinforcement is considered as alone carrying the bending moment, the stress in the reinforcement will be 16.6 kgr. per mm².

If we take into consideration the fact that the axle load of 19 tons adopted in these calculations is already exceeded in certain types of locomotives (the French rule for the calculation of metal bridges assumes a load of 26 tons for the calculations for the stringers and cross beams) and as this load is transferred as a dynamic load it must be admitted that the working stresses are excessive.

It will therefore be necessary to strengthen the reinforcement.

By increasing the diameter from 9 to 12 mm. (11/32 to 15/32 inch) which increases the cross-section of the metal to 5.65 cm² per group the new working stresses are as follows :

Concrete	43 kgr. per cm².
Steel	7 kgr. 9 per mm².
Steel without concrete.	8 kgr. 8 per mm².

The percentages of steel are 1.82 % for the « *Calot* » sleeper and 3.2 % for the sleeper with 12 mm. (15/32 inch) bars.

We should also recall that the German regulation of 1915, relating to calculations for reinforced concrete works, specifies the limit of 30 kgr. per cm² (427 lb. per sq. in.) as the stress on concrete and 750 kgr. per cm² (1 067 lb. per sq. in.) as the stress on steel in bridges under track submitted to dynamic loading.

3. — Investigation of the block sleeper.

The block sleeper of the « *Vagneux* » type consists essentially of two block supports of reinforced concrete measuring 32 × 64 cm. (1 ft. 5/8 in. × 2 ft. 1 3/16 in.) connected by a thin stay of reinforced concrete (9 cm. wide × 19 cm. high [3 1/2 in. × 7 1/2 in.]) or by a rolled I-joist 10 cm. (3.94 in.) deep weighing 8.3 kgr. per m. run (5.58 lb. per foot).

It may be assumed that in practice the vertical reaction of the wheel is uniformly distributed over the whole of the rectangular bearing surface of the block.

If the packing is the same under the two ends of the sleeper it follows that under simple vertical loading the stay will not be subjected to any stress.

However, it must be borne in mind that apart from the variable vertical forces, the vehicle when running exerts, on the track, horizontal forces of great magnitude due to swaying of the vehicles, so that the reaction of the ballast on the block will not be uniformly distributed, but will follow a more complex law depending on the deviation of the force exerted by the wheel from the centre of the bearing surface of the block.

As the resulting deformation of the bearing surface is not symmetrical with regard to the plane through the centre of the rail it follows that large bending forces will be exerted on the stay; these forces, in the case of old tracks carried on separate blocks, caused bending and stretching of the cross-stays which made themselves apparent by the spreading of the track and its being put completely out of gauge

It will be understood that the rigidity of the stays in the « *Vagneux* » sleeper prevents these troubles; it is, however, difficult to determine, even approxima-

tely, the stresses to which the stays will be subjected.

For example we shall presently examine the stress on a metal stay confining ourselves to the vertical forces exerted by the wheels and assuming the packing of the ballast to have become less compressed under one of the ends of the sleeper than under the other end.

In the extreme case in which the coefficient of the ballast under one of the blocks would be equal to 3 and under the other block equal to 8, the stress on the metal stay might be considered as that of a girder with horizontal encastré fixing and without intermediate forces, but in which one of the supports had got out of level with the other to an extent Y which can easily be determined.

The bearing surface of the base of the block on the ballast is 32 × 64 = 2 048 cm².

For one of the blocks

$$D_1 = 2\,048 \times 3 = 6\,144$$

For the other block

$$D_2 = 2\,048 \times 8 = 16\,384$$

Also

$$\gamma_1 = 6.8$$
$$\gamma_2 = 2.55.$$

The reactions R_1 and R_2, obtained on *Schwedler's* hypothesis for the case in which the axle is immediately over the sleeper are :

$$R = \frac{\gamma + 2}{3\gamma + 2} W$$

$R_1 = 0.255 W$ when $W = 9500$ kgr. $R_1 = 2420$

$R_2 = 0.472 W$ $R_2 = 4500$

$$Y_1 = \frac{R_1}{D_1} = \frac{2\,420}{6\,144} = 0 \text{ cm. } 393$$

$$Y_2 = 0 \text{ cm. } 275$$

$$Y = Y_1 - Y_2 = 0 \text{ cm. } 118.$$

For such unequal deflections in the stay the maximum encastré moment

$$M_A = \frac{6EIY}{L^2}.$$

$$EI = 2\,200\,000 \times 172$$

$$L = 86$$

$$M_A = 36\,000 \text{ kgr. cm.} \qquad \frac{I}{v} = 34 \text{ cm}^3.4$$

Stress

$$\tau = \frac{M}{\frac{I}{v}} = \frac{36\,000}{34.4}$$

approximately 10.5 kgr. per mm².

We will note that the stress on the metal does not depend either on the form or on the area of the section, but with all other proportions the same it depends solely on the height of the stay.

This result has already been obtained in the investigation of the secondary stresses in lattice girders.

The stress in question relates to a theoretical case which even under the hypothesis of simple vertical loads, will still be a limiting case obtained under exceptional circumstances.

In ordinary working the stay will be submitted to bending due to the normal horizontal forces which are exerted on the railway track.

The values of the coefficients of reaction D_1 and D_2 obtained are less than the calculated values for the reinforced concrete sleeper of rectangular section and for the wooden sleeper.

We may conclude from this that the deformation of the track will be greater in the case of a permanent way laid on block sleepers than in that of one laid on concrete sleepers of uniform section or on ordinary wooden sleepers.

If it is admitted that the packing becomes uniform after some time under

the whole of the length of the sleeper this conclusion will be justified.

We should, however, note that the « *Vagneux* » sleeper offers a large bearing surface under the blocks and, as these are accessible on all the four sides it is much easier to concentrate the packing under the ends than in the case with ordinary sleepers.

Under these conditions it is possible that the deformation of the track will be less than with sleepers of the other type.

This is what has been found on the Paris-Lyons-Mediterranean Railway on which a diagram taken by the *Hallade* apparatus on a section of the track 500 m. (550 yards) in length at *Montbard*, recently relaid, showed deformations sensibly less than in the adjacent parts laid on ordinary wooden sleepers.

4. — Method of laying the rail on the sleeper and fastening it to the sleeper.

The concrete sleeper of uniform section of the « *Calot* » type was designed primarily for carrying a double-headed rail with a chair having a large base.

It has also been tried for *Vignoles* rails on the French Northern Railway.

In both cases a packing piece of soft or hard wood is inserted between the chair and the sleeper or between the base of the rail and the sleeper.

This bearing for the chair on the sleeper, in the case of tracks carrying little traffic, where reinforced concrete sleepers have been used up to the present, has not given rise to any difficulty.

With the *Vignoles* rails, on the other hand, it has been found that when the rail bends it bears on the edges of the sleeper and causes flaking which exposes the reinforcing bars nearest to the edge of the sleeper.

Attempts are being made at the present time to find a method of overcoming this particular disadvantage.

The fastening of the screw-spike into the « *Calot* » sleeper is effected by means of a cast-iron sleeve fastened to the reinforcement before filling in the concrete.

Apart from the general objection to assembly of metal to metal, it should be noted that, in order to ensure satisfactory tightening, it is necessary that the screw-spikes and sleeves should be true to gauge sizes. This restriction does not apply in the case of wooden sleepers.

In the case of the « *Vagneux* » type of sleepers tried with *Vignoles* rails by the Paris-Lyons-Mediterranean Company, the bearing of the rail on the sleeper is effected by means of a metal sole-plate under the rail with the addition of a wooden packing piece on the sleeper.

The disadvantage mentioned above, as noticed on the French Northern Railway, has not been found with the « *Vagneux* » sleeper.

The screw-spikes are screwed directly into the sleeper.

The hole for the screw-spikes is provided with a *Thiollier* helix in the casting, and the securing of the screw-spike is effected by means of bitumen.

This method of fastening also requires careful gauging of the screw-spikes.

If the latter should be made of too large a diameter, cracks will be formed near the hole.

If, on the other hand, the diameter of the screw-spike is too small the fastening will not be secure.

It must, however, be recognised that this requirement is less important than it is for the sleeve attachment in the « *Calot* » type of sleeper.

Trials of the resistance to pulling out of the screw-spikes made on both types of sleeper by means of the *Collet* extrac-

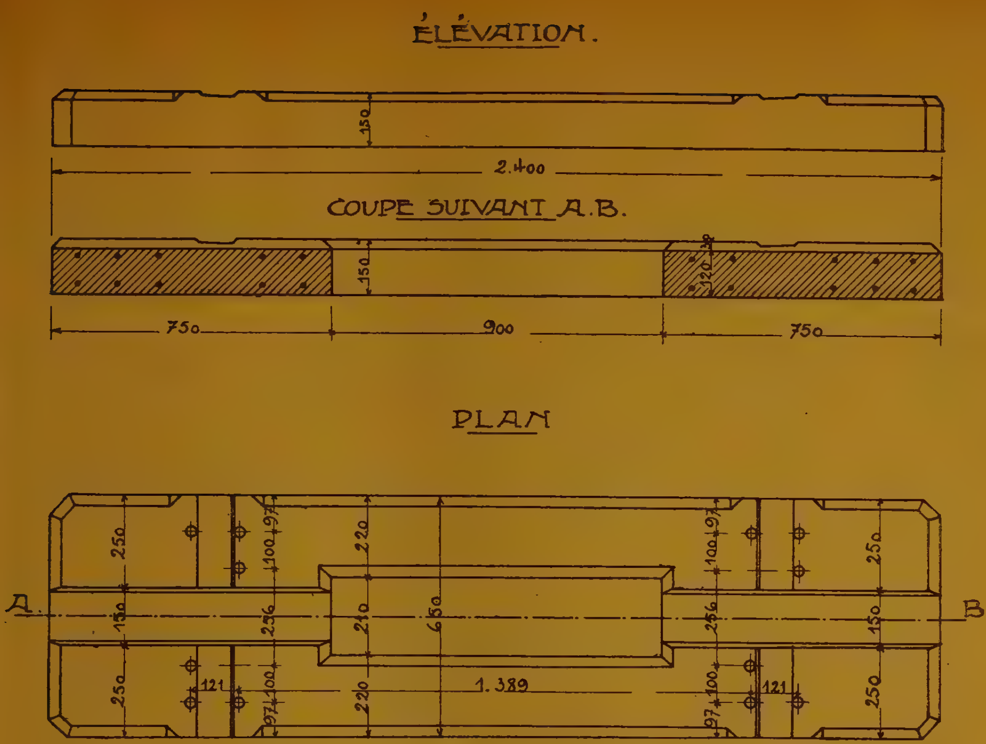


Fig. 5. — French Northern Railway. — Reinforced-concrete rail-joint sleeper for rails weighing 30 kgr. per m. (60.48 lb. per yard).

Explanation of French terms : Coupe suivant A-B = Section on A-B.

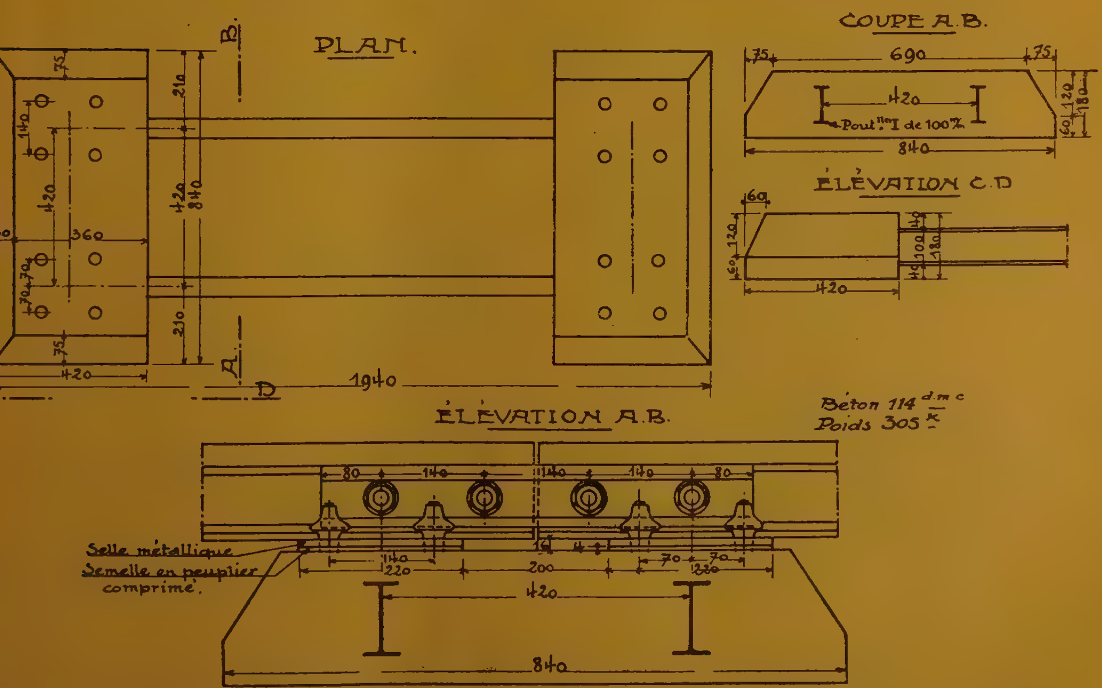


Fig. 6. — Reinforced-concrete rail-joint sleeper « Vagneux » patent system. — June 1921. — Standard model.

Explanation of French terms : Coupe suivant A-B = Section on A-B. — Poutrelles I de 100 m/m = I-joists 3.94 inch deep. — Élévation A-B = Elevation on A-B (C-D). — Béton = Concrete. — Poids = Weight. — Selle métallique = Metal bearing plate. — Semelle en peuplier comprimé = Wood packing of compressed poplar.

tor (force-measurer) have given full satisfaction to the inventors.

We conclude, from the results obtained up to the present, that the laying of the rail on the sleeper should be effected with the insertion of a metal plate under the sole of the rail and of a wooden packing-piece on the sleeper in order to avoid the effects of local crushing which the concrete is unable to withstand.

With the same object it is advisable to give sufficient width to the sleeper or to the sleeper block which could constitute local reinforcement of the lateral portions of the concrete directly subjected to compression.

With regard to the fastening of the screw-spikes into the sleepers it would appear, notwithstanding the necessity for special precautions in gauging the screw-spikes, that the most satisfactory fastening is effected by means of a *Thiollier* helix, enclosed in the concrete, put into place before casting.

The fastening of the earliest Italian sleepers on wooden blocks dovetailed into the concrete sleeper did not give satisfactory results and the same was found with direct screwing on to asbestos conrete (see « Versuche mit Asbeston *Schwellen* bei der Württembergischen Staatsbahn ». *Organ für die Fortschritte des Eisenbahnwesens*, Heft 1, 1921.)

5. — Rail-joint sleepers.

Apart from the reinforced concrete sleepers already described the « *Calot* » and « *Vagneux* » types also comprise special rail-joint sleepers, which, in the « *Calot* » system, consist of two sleepers connected by a longitudinal member under the joint, and in the « *Vagneux* » system by two longitudinal blocks connected by one or two cross stays either of reinforced concrete or of rolled section steel.

These special rail-joint sleepers considerably increase the stability of the ordinary cantilever joints.

Moreover, it would be incorrect to imagine that it is necessary to strengthen the rail-joint to an excessive extent in order to diminish deformation of the track.

The ideal of track deformation would be that in which the track should sink parallel to itself while keeping the vertical movement of vibration of the vehicles within the smallest limits.

The most usual deformation that takes place with wooden sleepers is that which produces a convex upward curvature of the rail with low joints.

By increasing the rigidity of the joints excessively, the phenomenon would simply become the reverse.

The joints would then become the high points of the deformation and the rail would assume a curve concave upwards.

It is, moreover, probable that without arriving at this extreme result it would be possible to give the special rail-joint sleeper a form satisfying these conditions.

With the object of effecting economy in the equipment of the track inventors have in view the construction of tracks of a mixed type with alternate sleepers and separate blocks not connected by cross-stays.

It would appear that this expedient could only be applied on light railways carrying little traffic.

CONCLUSIONS.

From the technical point of view it appears that the reinforced concrete sleeper, when well designed, may give results quite comparable with those of the ordinary wooden sleeper.

The inventors maintain that the cost of maintenance of the track will be less than in the case of wooden sleepers; this point can, however, be settled by experience alone.

It is, moreover, probable that the type of sleeper likely to have the best future prospects will resemble the « *Vagneux* » sleeper with a rolled section cross-stay.

In addition to the facility for packing given by its form, this sleeper is not liable to break under the reaction of the ballast as was the case with the earlier rectangular sleepers.

Perfect safety, in this respect, will be given by the steel cross-stay or rolled section which can undergo considerable distortion without breaking.

Nevertheless, the reinforced concrete sleepers present two extra disadvantages over wooden sleepers : the difficulty of fixing the rail to the sleeper and the doubling of the weight which renders the handling more difficult.

The « *Calot* » sleeper at present costs appreciably more than a wooden sleeper.

The inventor states that the «*Vagneux*» sleeper is comparable in price with the wooden sleeper.

The advantage would be turned, moreover, in favour of the « *Vagneux* » sleeper if the expectations of the inventor regarding maintenance of the track should prove correct.

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Distinctive features of the Elvin mechanical stoker.

Figs. 1 to 6, pp. 973 to 978.

(*Railway and Locomotive Engineering*, EDITORIAL.)

A description of the Elvin mechanical stoker as applied to a number of locomotives on the Erie Ralroad was published in *Railway and Locomotive Engineering* for March 1919. Since that time a few changes have been made in some of the details without changing the fundamental principles of its operation.

It is the purpose of this article to present a review of the essential features and operation of the machine in greater detail than given in the earlier article.

The machine is essentially a mechanical stoker in that coal is taken from the tender and put into the firebox of the locomotive through the fire door by mechanical means only, whereas in all other stokers, now upon the market, the coal is distributed over the surface of the grates by means of a steam blast.

In the adaptation of mechanical means to the distribution of the coal in the firebox the purpose has been to imitate skilled hand-firing as nearly as possible. This involves the scattering of the coal over the surface of the bed in a uniform shower with especial attention to the placing of suitable quantities in the rear corners and along the back and side sheets. In order to do this the design of the shovels by which the coal is thrown into the firebox, as well as their motion, had to be carefully studied.

The form of the shovel is clearly shown in the engraving illustrating the relative positions of the shovel and elevator when the latter is near the upper end of its stroke. The shovel is pivoted at one end and swings with a vertical shaft set just outside the firedoor, and has an arc of action through about 145°. In plan the shovel has a gradually widening base with a vertical backing which follows the back contour with its full height of about 4 inches for nearly the whole length, and then has a lower ridge, about 1 1/2 inches high, following well around the curve. These shovels pick up the coal from the top of the elevator and throw it into the firebox in a manner that will be described later.

Taking up the design of the stoker in detail, its operation begins at the floor of the tender where the coal is delivered to it through long and narrow openings in the same.

Power is taken from a worm on the engine shaft on the locomotive and delivered to the mechanism on the tender through a pair of gimbel universal joints, 1 and 2, connected by a shaft having a slip joint, 3. This construction permits a wide range of movement, both laterally and longitudinally, between the engine and tender and still maintains a nearly uniform motion of the tender parts. Beyond the joint 2 there is a length of shafting 6 to which a beveled pinion 5 is keyed. This pinion drives a train of gearing, the details of which it is unnecessary to describe, which includes the spur gear 7 and the beveled gear 8. The latter

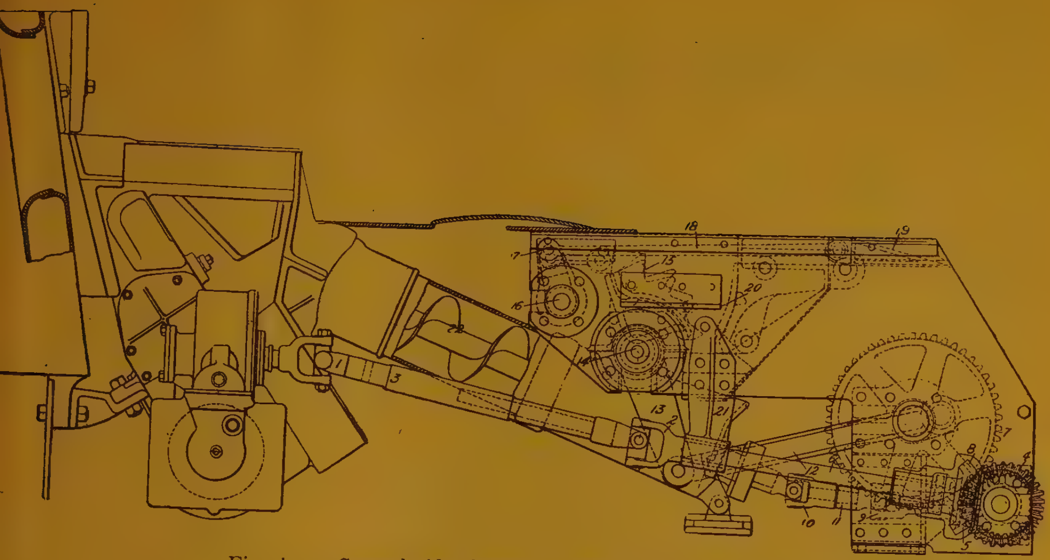
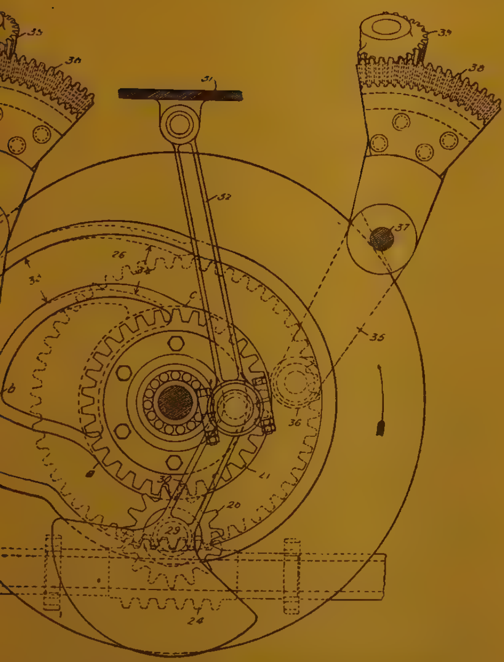


Fig. 1. — General side elevation of Elvin mechanical stoker.



g. 2. — Rear elevation of operating mechanism of Elvin mechanical stoker.

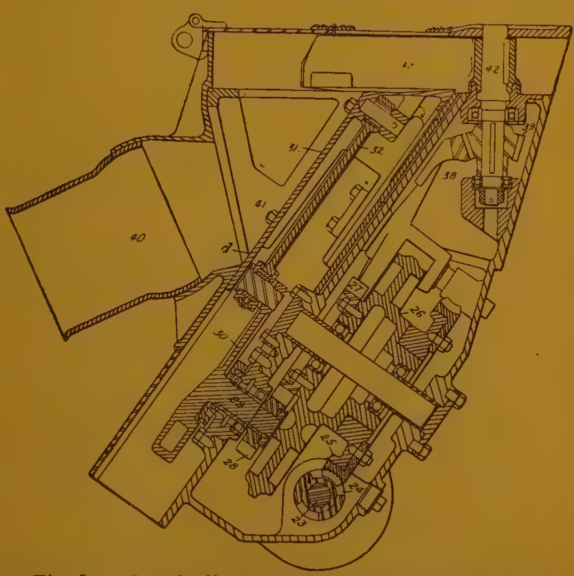


Fig. 3. — Longitudinal section of operating mechanism, Elvin mechanical stoker.

is keyed to a shaft driving the conveyor worm through the universal gimbel joints 9 and 10, and the shaft carrying the slip joint 11.

The spur gear 7 carries a crankpin, by which the connecting rod 12 is made to oscillate the lever arm 13. This lever arm 13 is keyed to the shaft 14, which runs transversely to the centre line of the tender and to which the coal crusher jaw 15 is also keyed. A rocking motion is thus given to the crusher.

A pin connection on the crusher casting serves for the attachment of a connecting rod running ahead to a rocker arm on the shaft 16 to which a second rocker arm 17 is also keyed. From the upper end of this last arm a connection 18 runs back to the coal feeding device 19 and gives it a slow forward and backward movement with a travel of about 4 inches. It will be seen that these coal feeders have a gentle inclination to the rear with a vertical face at the front, so that, as they move to and fro, they slip back beneath the coal on their backward motion and carry it with them as they move forward. This produces an intermittent forward movement of the coal towards the opening between the moving crusher jaw 15 and the stationary plate 20. The lumps of coal falling into this space that are too large to drop on down between the moving and stationary jaws are crushed until they are in pieces small enough to so pass through.

The coal as it leaves the crusher drops into the hopper 21 above the conveyor screw 22 and then the latter carries it forward from the tender and delivers it to the elevator on the engine, which forms a part of true stoker mechanism.

This is shown by two engravings illustrating a section on a line with the centre line of the engine and a rear elevation, both of the operating and distributing mechanism.

This portion of the machinery is driven direct from the engine shaft 23. This shaft in addition to the worm driving the tender mechanism also carries a worm 24 that meshes with and drives the wheel 25. The latter is rigidly attached to a cam disk 26 in which the cams are located for the operation of the shovels. This disk also carries the spur gear 27, that meshes with a pinion 28 of one-half its own diameter, so that the revolutions per minute of the latter are twice those of the gear. The pinion is keyed to the shaft 29 to which the crank arm 30 with its counter balance is keyed. This crank drives the elevator 31 through the connecting rod 32.

From the longitudinal section of the machine it will be seen that the elevator rises on an angle of 34° with the vertical, while the top, on which the coal rests, is always horizontal.

All this is very simple. The shovel movement, howewer, needs a little more careful study, and can be best understood from a study of the rear elevation.

The cam disk carries two similar cams on its opposite (front and rear) faces. These are indicated, in the engraving, by the spaces 33 and 34 outlined by full and dotted lines respectively. The cams impart an oscillating movement to the lever arms 35 through the rollers 36 attached to the ends of the same and which run in the cam grooves. The lever arms 35 are pivoted on the horizontal shafts 37. The outer ends of the levers carry sections of beveled gears 38. These mesh with the sections of beveled pinions 39 which are keyed to the vertical shafts to which the shovels are attached. The oscillating movement of the arms 35 is thus communicated to the beveled gear segments, and these are so proportioned that they oscillate the pinions and shovels to and fro through an angle of 145°, as already stated.

The two cams, it will be seen, are almost identical in shape and location, the difference between them being due to the difference in the angles at which the shafts 37 stand from the main central shaft about which the cam rotates. The direction of

cam rotation is indicated by the arrow and is contrariwise to the movements of the hands of a clock.

While the rollers are against that portion of the cam which is concentric with the center of the cam disc, they are, of course, stationary, which is the condition of the right hand roller in the illustration, in which position the shovel is drawn back to the side of the elevator waiting for the latter to come up with a load of coal. As the cam revolves, the roller and shovel remain stationary until the point *a* is reached. The roller is then moved rapidly outward while passing over that portion of the cam between *a* and *b*. At *b* it has reached the extreme of its throw as shown by the left hand lever and the shovel has swept through the 145° of its movement. Then, as the cam advances the roller is drawn towards the center and the shovel back away from the elevator, until, at *c*, both are again at rest.

The movement of the two shovels thus alternates, first one and then the other throwing coal into the firebox. Meanwhile the elevator, making two strokes to each revolution of the cams, offers a load of coal to each shovel as it is swung forward.

It is here that the resemblance to hand firing comes in. The coal is picked up from the top of the elevator by the shovel as it swings forward and it is carried upon the bottom surface of the same. The rib at the back prevents it from sliding off the shovel and the centrifugal action gives it a tendency to slide out towards the end. This, combined with the movement of the shovel itself, scatters it in a sort of shower over the surface of the bed of coal on the grate. But the low, hook-shaped rib, at the outer end, catches some of the coal as it slides over the surface of the bottom and holds it until the end of the shovel travel is reached, when it is thrown into the back corner of the firebox, as the end of the shovel is, then, well inside the door. One shovel, therefore, feeds the back right and the other the back left hand corner of the firebox.

The movement of the coal is, then, as follows :

It is dragged forward by the feed conveyor 19, until it drops into the crusher and thence into the hopper 21, from which it is carried forward by the screw conveyor 22 and discharged through the tube 40 into a triangular terminal of the conveyor casing 41. The coal moves continuously forward across this space to the top of the elevator. The elevator, in its motion up and down, descends so that its upper surface comes down flush with the bottom of the conveyor tube at *d*. In this position coal is delivered direct and, as the elevator rises, it moves forward over the space and, as it descends again, the coal moves rapidly over on to the top of the elevator.

At the upper end of the stroke of the elevator there is a very close adjustment between its movements and that of the shovels. It is evidently necessary that, with the elevator driven by a crank it is in constant motion, and that the coal must be removed during a brief period of its near approach to and recession from its highest position.

The relative movements of elevator and the shovels also require that the two shall be so shaped that they may come into close proximity with each other and yet not touch. These shapes and the adjustment are shown in the series of engravings over the caption : « Line of shovel travel. »

The crank, which drives the elevator, is shown as rotating in the direction of the hands of a clock. Before the elevator reaches the upper end of its stroke, the shovel starts to move forward from its stationary position; and, when the crank is in position *A*, the shovel has moved forward to the point indicated. That is it has just started to cross over the surface of top of the elevator. At this point the elevator is still rising and the crank

lacks 8° of being at the center. In position *B* the elevator is at the extreme upper limit of its throw, which is 1/4-inch above the line of shovel travel, and the shovel has advanced well over its upper surface. In order that the two parts may not come in contact the heel or back side of the shovel is higher than

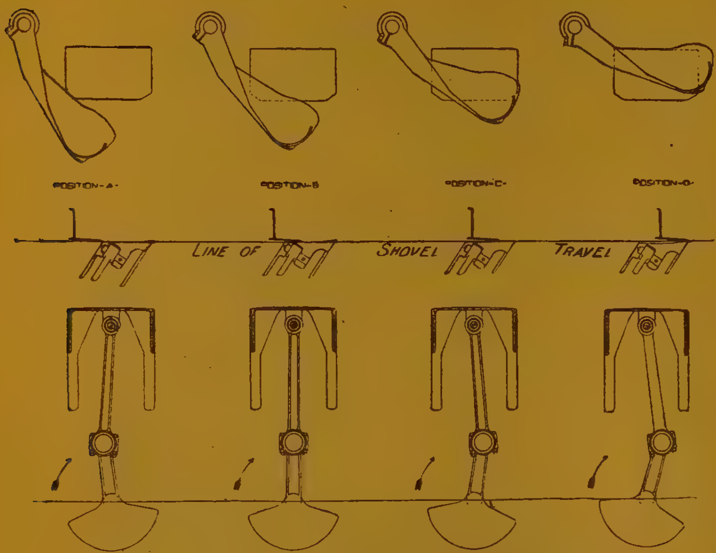


Fig. 4. — Line of shovel travel of Elvin mechanical stoker.

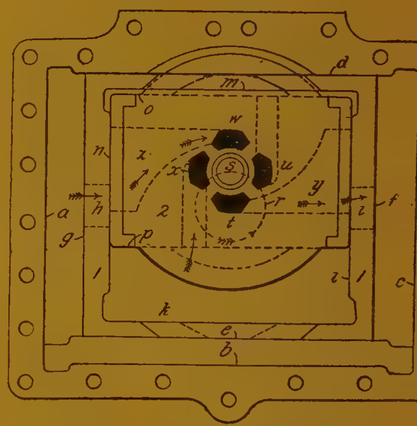


Fig. 5. — Side elevation of Elvin stoker engine with cover removed.

the front on the under surface and the top of the elevator is cut away so as to make it slightly concave.

From this point the elevator is falling, and so, in order that it may not get too far away from the bottom of the shovel, its front side is raised above the center, and, in position *C*, with the crank 8° beyond the center and the shovel edge at about the center of the elevator, the two are still close together. In position *D*, the crank has advanced to 14° beyond the center, the elevator has dropped to the level of the line of shovel action and the shovel has moved across the whole face of the elevator and picked up all of the coal from its surface.

Then, as the empty elevator moves down, the shovel advances through the door of the firebox, distributes the coal and returns to its stationary position, as already described.

Under ordinary working conditions, the elevator makes about 40 strokes per minute and delivers from 3 pounds to 5 pounds of coal to the shovels at each stroke, dependent upon the rate at which it is fed into the hopper at the back of the screw conveyor.

As all parts are geared together there is no possibility of any variation in the synchronism of their action and the shovels are housed in a box which protects them from accident and prevents any one from being struck by them or by chance flying particles of coal. This box has a floor about 1/4-inch below the line of travel of the shovels, and is closed by a hinged cover by which the flow of air through the door openings into the firebox is cut off.

One of the most interesting features of the stoker mechanism is the engine which is used to drive it. It is of unique

design and of a remarkably compact construction.

Its working parts consist of two pistons, one working within the other and with movements at right angles to each other. The engraving shows a side elevation of the cylinder or box with the cover removed. The outline of the interior of the box is marked by the lines *a, b, c, d*. The space between the lines *b* and *e* is filled by a liner so that the line *c* becomes the working face for the piston. The sides of the box are flat, and form the bearing surfaces for the pistons, the sectional areas of which are rectangles.

The outline of the main piston is marked by the lines *e, f, d, g*, and it reciprocates to and fro in the box from right to left and left to right.

Steam is admitted to and exhausted from the ends of the pistons through the ports in the end walls marked *h* and *i*. The steam enters and leaves through the ports at the center which are shown in black.

The main piston 1, forms a box or cylinder in which the second piston, 2, reciprocates vertically. The outline of this interior box is indicated by the lines *k, l, m, n*, and the top and bottom of the piston by the lines *o* and *p*, above and below which are curved portions rising and dropping into domes in the main piston.

The shaft enters at the rear of the box and carries the crank pin *s* which enters a bearing in the inner piston and describes the crank circle *r*, which is 2 1/2 inches in diameter; the speed being at the rate of about 500 revolutions per minute.

In the engraving the outer piston is shown at the center of its stroke and the inner piston at the extreme upper end of its stroke. In this position the crank is turning in the direction indicated by the arrow on the crank circle, and steam admitted at the port *t* follows the line of arrows through the passage *y* in the inner piston through the port *i* in the outer piston to the right hand end of the box, thus pushing the piston to the left. At the same time the port *w* is open to the exhaust and steam is flowing to it from the left hand end of the box through the port *h* in the outer piston and the port *z* in the inner.

The port *x* of the inner piston is also open to the exhaust which is flowing to it through the port leading down therefrom, as indicated by the arrow. The port *u*, which serves the upper side of the inner piston has not yet opened, but does so, shortly after the crank has passed the center.

The crank is thus acted upon by two pistons moving at right angles to each other, and in what is virtually a double Scotch yoke, so that it will always start.

The detail of the valve action of this engine can be readily followed from the diagrams presented . In these the view is taken from a direction opposite to that used for the engine itself, so that the crank *B* is represented as turning in the direction of the curved arrow *A*.

The various positions of the crank in the diagrams are numbered from 1 to 16 consecutively. The ports in the inner piston are lettered *C, D, E*, and *F*. The port *C* serves the top of the inner piston; *D* serves the right hand side (as viewed in the diagram) of the outer piston; *E*, the bottom of the inner piston and *F* the left hand side of the outer piston. In the diagrams the space enclosed by the circle *G* is the opening of the steam admission port in the box; the circle *H* is the crank circle, and the space between the circles *I* and *K* is the exhaust opening in the box. The double cross-hatched portions of the ports in the inner piston represent the portions of those ports that are opened to the admission or exhaust ports in the box.

In position No. 1, the crank *B* is about 10° from and is approaching the upper center. At this point, the port *D* is fully open to the exhaust and steam is flowing into it from the right hand side of the

outer piston, while the admission port *F* is admitting a full flow of steam to the left hand side of the same piston. The port *C* is still slightly open to the exhaust from

Fig. 6. — Illustration of opening and closing of ports on Elvin mechanical stoker.

the top of the inner cylinder, while the port *E* is at the point of cut-off for the lower side of the inner piston.

In position No. 2 the crank still lacks about 5° of reaching its upper center, and the same condition prevails as before in the case of ports *D* and *F* serving the outer piston and both ports of the inner piston are closed; the exhaust port *C* serving the top of the inner cylinder is

just at the closing point of the exhaust.

In position No. 3, the crank has passed about 5° beyond its upper center and the two ports *D* and *F* serving the outer piston are still functioning as before; the ports *C* and *E* are closed but the port *E* is on the line to open the exhaust to the bottom of the inner piston.

In position No. 4, the crank has passed to about 10° beyond its upper center, with the ports *D* and *F* still open to the exhaust and admission. The port *E* has opened the exhaust from the bottom of the inner piston to a slight extent, and the port *C* is just opening the admission to the top of the inner piston.

Immediately upon passing position No. 4, all four ports are open; *D* and *E* to the exhaust and *C* and *F* to the steam. This condition prevails until position No. 5 is reached.

In position No. 5 the crank has reached a position about 10° from the right hand center; the ports *C* and *E* serving the top and bottom of the inner piston are wide open to the admission and exhaust ports respectively; the cut-off of the port *F* to the left hand end of the outer piston has just taken place and the port *D* has nearly closed the exhaust from the right hand side of the outer piston.

In position No. 6, the crank is about 5° from the right hand center and both ports serving the outer piston are closed, the exhaust *D* from the right hand side having just closed, both ports serving the inner piston being open to the admission and exhaust as before in No. 5.

In position No. 7 the crank has passed about 5° beyond the right hand center. Both ports serving the outer piston are still closed, but the port *F* is on the line to open the exhaust from the left hand side and both ports serving the inner piston are wide open as before.

In position No. 8 the ports *C* and *E* are still open to the admission and exhaust; the port *F* has opened the exhaust from the left hand side of the outer piston and the port *D* is on the line to open the admission to the right hand side of the outer piston. In this position the crank has passed about 10° beyond the right hand center.

Between this and position No. 9 all ports are open. Ports *C* and *D* to the admission and *E* and *F* to the exhaust.

In position No. 9 the ports *D* and *F* serving the outer piston are open as before; the port *E* has nearly closed the exhaust from the bottom of the inner piston and the port *C* is on the line of cut-off for the top of the inner piston. At this point the crank is approaching the lower center and is about 10° therefrom.

In position No. 10, the ports serving the outer piston are still open as before, and both ports serving the inner piston are closed, the port *E* being on the line of the exhaust closure for the bottom of the inner piston. The crank is about 5° from and approaching the lower center.

In position No. 11, the same condition prevails as in position No. 10 except that the crank has passed to about 5° beyond the lower center and the port *C* is on the line to open the exhaust from the top of the inner piston.

In position No. 12, the crank has passed to a point about 10° beyond the lower center, the two ports serving the outer piston are still wide open; the exhaust from the top of the inner piston has been slightly opened through the port *C* and the port *E* is on the line to open the admission to the bottom of the inner piston.

Between this and position No. 13, all ports are open as indicated in No. 12.

In position No. 13 the crank is approaching the left hand center and is distant about 10° from it. The ports serving the inner piston are wide open to the admission to the bottom and the exhaust from the top. The port *F* has nearly closed the exhaust from the left hand side of the outer piston and the port *D* is on the point of cut-off from the right hand side.

In position No. 14, the crank lacks 5° of reaching the left hand center. The ports serving the top and bottom of the

inner piston are wide open and both ports serving with the outer piston are closed; the port *F* being at the point of closure of the exhaust from the left hand side of the outer piston.

In position No. 15, the crank has passed to a point about 5° beyond the left hand center. Both ports serving the inner piston are wide open and both serving the outer piston are closed with the port *D* just opening the exhaust from the right hand side of the outer piston.

In position No. 16, the crank has passed to about 10° beyond the left hand center. The ports serving the inner piston are open as before in No. 15. The port *D* has opened the exhaust from the right hand side of the outer piston to a slight extent and the point of admission has been reached for the port *F* serving the left hand end of the outer piston.

From this to position No. 1, all ports are open.

Thus it appears that the admission ports open when the crank is about 10° beyond the center and the cut-off occurs at about 10° before the crank reaches the opposite center. The exhaust opening occurs about 5° after the crank has passed its center and closes about 5° before it has reached the opposite center. Therefore, the admission is open through 160° of the revolution of the crank, and the exhaust is open through 170°, leaving about 15° of travel at each end where both ports are closed. But, when one set of ports for one piston are closed the other is wide open and the piston is working at greatest leverage.

The engine is beneath the cab. Its action is smooth and it develops sufficient power with a very small space to run the stoker up to speed with any variety of coal.

The stoker in the form that is here described has recently been applied to a number of Mallet locomotives built for the Chinese Railway which are the largest Mallets ever exported from this country.

[656 .253 (.73)]

I. C. C. proposes to order automatic train control.

(*Railway Age.*)

The Interstate Commerce Commission on 10 January served upon 49 railroads an order to show cause by 15 March why it should not adopt a report and enter an order requiring them to install by 1 July 1924, between designated points in their main lines, automatic train stop or train control devices complying with specifications and requirements set forth in the order which the commission has determined upon as the result of its investigation conducted pursuant to section 26 of the interstate commerce act.

The device, according to the proposed order, is to be applicable to or operated in connection with all road engines running on or over at last one full passenger locomotive division included in the part of the main line between the points named. It further provides that each carrier named shall submit to the commission complete and detailed plans and specifications prior to the installation and that by 1 July 1922, they shall file complete and detailed plans of the signal systems in use and a report of the number and type of locomotives assigned to or engaged in road service on the designated portions of line and shall proceed diligently and without unnecessary delay to select and install the devices

as specified. They are also to file with the commission on or before 1 July and each three months thereafter full and complete reports of the progress made with the preparation for and the installation of the devices, which together with the manner and details of the installation shall be subject to the approval of the commission or the division of the commission to which the matter may be referred.

Report of the Commission.

The report of the commission says :

« This is a proceeding initiated by us under Section 26 of the interstate commerce act under which we are authorized after investigation to order any carrier by railway subject to the act to install automatic train-stop or train control devices or other safety devices.

« Under Public Resolution No. 46, approved 30 June 1906, the Congress directed us to investigate and report on the use of and necessity for block signals for automatic control of railway trains in the United States. The sundry civil appropriation act, approved 26 May 1908, contained a provision directed to the same end and appropriated some fifty thousand dollars for the purpose. Under the above resolution the Block Signal and Train Control Board was created and was employed by the commission from 1907 to 1912 to study the subject and to investigate numerous automatic train-stop and train-control devices presented by various designers and patentees. Reports of these investigations have been made to us with recommendation as to specifications and requirements. Since 1912 the commission's Bureau of Safety has continued these investigations. Under the United States Railroad Administration investigations were made by a special Automatic Train-Control Committee and further specifications and requirements were recommended. The records and files of this committee have been transferred to this commission. »

Investigation has proved worth.

« The conclusions arrived at as a result of these several investigations conducted from 1906 to 1920, were identical in substance, namely, that automatic control of trains is practicable; that the use of automatic train control devices is desirable as a means of increasing safety and that the development of automatic train-control devices had reached a stage warranting installation and use of such devices on a more extended scale. The results of these investigations and the conclusions thereon were published from time to time and attracted widespread attention commensurate with the importance of the subject. The successive investigations with their satisfactory results, and the recognized obvious need for some such device resulted in the inclusion in the transportation act of 1920 of a section which places upon us the duty after investigation of ordering the installation by the carriers, in locations designated by us, of automatic train-stop or automatic train-control devices which comply with prescribed specifications and requirements.

« Since that section was passed we have been urged to require the installation of various automatic train-control devices. We were not disposed, however, to issue an order requiring the installation by any carrier of any such device without further investigation and a review of past investigation and performances together with a thorough check under our own supervision of the actual performances of these devices as installed and in operation.

« To that end and in order to carry out the provisions of Section 26 in the most effective and expeditious manner, we invited the co-operation of the American Railway Association. A joint committee on automatic train control consisting of representatives of the signal section and

the operating, engineer and mechanical divisions of that association was appointed in November 1920.

« The joint committee has been engaged in connection with our Bureau of Safety, since November 1920, in studying the performances of train-control devices under varying service conditions and has rendered us valuable aid. We have had the advantage of the specifications and requirements developed from these practical demonstrations.

« Record has been kept by our Bureau of Safety of service operations on portions of the lines of the Chesapeake & Ohio, the Chicago, Rock Island & Pacific, and the Chicago & Eastern Illinois railroad companies, equipped with different automatic train-stop and train-control devices, each of which shows a high degree of efficiency. Data have been gathered upon the effect of the devices upon railroad operating conditions, upon problems of installation and maintenance on an extended scale, upon installation, operating and maintenance costs and upon the revisions made or required in the several devices.

Savings from safety.

« The matter of cost is the basis upon which the carriers have raised objection to an order requiring the installation of automatic stop or train-control devices. Like objection has been made to the installation of all other safety devices which are now in use and which have long since demonstrated their practicability and necessity. This objection has been raised in prosperous as well as in non-prosperous years. Yet the compensation from a financial standpoint, which will result from the securing added safety in train operations should not be overlooked. In the hearings before the Committee on Interstate and Foreign Commerce when Section 26 was under consideration certain statistics gleaned from our accident reports were presented showing that from 1909 to 1917, both inclusive, there were 13 339 head-on and rear-end collisions resulting in damage to railroad property alone of over nineteen million dollars. These collisions resulted in death to 2 454 persons and injury to 37 724. In other words, the annual average of these collisions amounted to 1 482, the average number of killed to 272, and of injured to 4 191. During the two and one-half years from 1 January 1918, to 30 June 1920, inclusive, there were 3 226 such collisions, resulting in the deaths of 635 persons and injury to 6 240. The damage to railroad property amounted to over seven million dollars. If to the large property loss there be added the death losses and the damages paid for persons injured the total rises to enormous figures. If these vast sums which represent total losses to the carriers had been expended in the installation of block signal systems or automatic train-stop or train-control devices many thousands of miles of road could have been equipped.

« In the report of the chief of the Bureau of Safety for the fiscal year ended 30 June 1921, it is shown that during the fiscal year 97 train accidents were investigated of 62 collisions and 35 derailments. The collisions resulted in the death of 194 persons and the injury of 849 persons. The derailments resulted in the death of 77 persons and the injury of 518 persons, a total of 271 killed and 1 367 injured. Twenty-six of the collisions occurred on lines operated by the block signal and of these 17 occurred where automatic signals where used. Of the 17.8 were rear-end collisions, 4 were head-end collisions, and 3 were side collisions. Of these 17 collisions occurring in block signal territory there were 13 cases in which enginèmen, pilots or motormen failed properly to observe or obey signal indications. These undoubtedly would have been prevented had an adequate automatic train control system been in use.

Recent accidents.

« Since the above report was made several accidents resulting in large loss of life and property have occurred. A rear-end collision between two passenger trains on the Pennsylvania Railroad near Manhattan Transfer, New Jersey, in which 46 persons were injured could doubtless have been prevented had the automatic train control system in use from the Pennsylvania Terminal, New York City, to the Hackensack River been extended to the Manhattan Transfer, a distance of some two miles. In December 1921, a wreck occurred on the Philadelphia & Reading road a few miles out of Philadelphia, resulting in the death of 23 persons and injury to many others. Had there been an adequate automatic train-control device on that road this wreck would not have occurred.

« Our investigations have shown that automatic train control has long since passed the experimental stage. In fact, no safety devices, such as the automatic coupler, the air brake and the automatic block signal, were perfected to as high a degree as the automatic train control before they were either ordered installed or were voluntarily adopted. »

Practicable and necessary.

« The fourteen years of investigation and study, the service tests under varying conditions and the results obtained in the actual employment of these devices over periods of years upon some of the roads have clearly demonstrated the practicability of and the necessity for automatic train-stop or train-control. The time has now arrived when the carriers should be required to select and install such device or devices as will meet our specifications and requirements. Under the act our order cannot be made effective before the expiration of two years from the date thereof. The fixing of a time limit must be based upon a consideration of the time which has already run since the passage of the act, and the progress and present state of automatic train control. There must be considered also the time reasonably required to enable the carriers to select suitable devices from among those available, to develop them and to meet their operating conditions and requirements in the designated locations and to provide for the manufacture and installation of the apparatus.

« The definitions, functions, requirements and specifications which we have adopted are set forth in the appendix. They are based upon the facts developed in our investigations and upon the requisites laid down by the Block Signal and Train Control Board report in 1912, the requisites of the Railroad Signal Association adopted in 1914, and those of the Automatic Train Control Committee of the United States Railroad Administration in 1919, together with the definitions and functions reported by the Joint Committee on Train Control of the American Railway Association in March 1921.

« The railroads hereinafter designated which are required to install upon the designated portions of their roads, automatic train control devices in accordance with our specifications and requirements, have been selected with regard to the measure of the risk of accident in connection with traffic conditions thereon.

« We have decided not to limit by our order the installation of these devices to roads or parts of roads already equipped with automatic block signals, because we have no desire to discourage efforts for automatically controlling trains without the aid of the fixed wayside signals. The statement, therefore, as to the primary function of automatic train-stop or train-control devices recognizes the possibility of establishing such a device without the use of automatic block signals in conjunction therewith. »

The roads affected.

The list of railroads to which the order was issued and the parts of their lines designated is as follows:

« Atchison, Topeka & Santa Fe, between Chicago and Newton, Kan.

« Atlantic Coast Line, between Richmond, Va., and Charleston, S. C.

Baltimore & Ohio, between Baltimore and Pittsburgh.

« Boston & Albany, between Boston and Albany.

« Boston & Maine, between Boston and Portland, Me.

« Buffalo, Rochester & Pittsburg, between Rochester and Butler, Pa.

« Central Railroad of New Jersey, between Jersey City and Scranton.

« Chesapeake & Ohio, between Richmond, Va., and Clifton Forge, Va.

« Chicago & Alton, between Chicago and Springfield, Ill.

« Chicago & Eastern Illinois, between Chicago and Danville, Ill.

« Chicago & Erie, between Chicago and Salamanca, N. Y.

« Chicago & North Western, between Chicago and Omaha.

« Chicago, Burlington & Quincy, between Chicago and Omaha.

« Chicago, Indianapolis & Louisville, between Chicago and Louisville, Ky.

« Chicago, Milwaukee & St. Paul, between Chicago and St. Paul.

« Chicago, Rock Island & Pacific, between Chicago and Rock Island, Ill.

« Chicago, St. Paul, Minneapolis & Omaha, between Minneapolis and Omaha.

« Cincinnati, New Orleans & Texas Pacific, between Cincinnati and Knoxville, Tenn.

« Cleveland, Cincinnati, Chicago & St. Louis, between Cleveland and St. Louis.

« Delaware & Hudson Company, between Wilkes-Barre, Pa., and Albany.

« Delaware, Lackawanna & Western, between Hoboken and Buffalo.

« Erie Railroad, between Jersey City and Buffalo.

« Galveston, Harrisburg & San Antonio, between El Paso, Texas, and Houston.

« Great Northern, between St. Paul and Minot, N. D.

« Illinois Central, between Chicago and Memphis.

« Kansas City Southern, between Kansas City and Texarkana, Texas.

« Lehigh Valley, between Jersey City and Buffalo.

« Long Island, between Jamaica and Montauk.

« Louisville & Nashville, between Louisville and Birmingham.

« Michigan Central, between Chicago and Detroit.

« Missouri Pacific, between St. Louis and Kansas City.

« New York Central, between Albany and Cleveland.

« New York, Chicago & St. Louis, between Chicago and Cleveland.

« New York, New Haven & Hartford, between New York and Providence, R. I.

« Norfolk & Western, between Roanoke, Va., and Columbus, Ohio.

« Northern Pacific, between St. Paul and Mandan, N. D.

« Oregon-Washington Railroad & Navigation Company, between Portland and Pendleton.

« Pennsylvania Railroad, between Philadelphia and Pittsburgh.

« Pere Marquette, between Grand Rapids and Detroit.

« Philadelphia & Reading, between Philadelphia and Harrisburg.

« Pittsburgh & Lake Erie, between Pittsburgh and Youngstown, Ohio.

« Pittsburgh, Cincinnati, Chicago & St. Louis, between Pittsburgh and Indianapolis.

« Richmond, Fredericksburg & Potomac, between Washington and Richmond, Va.

« St. Louis & San Francisco, between St. Louis and Springfield, Mo.

« Southern Pacific Company, between Oakland and Sacramento.

« Southern Railway Company, between Washington and Atlanta, Ga.

« Union Pacific, between Omaha and Cheyenne.

« West Jersey & Seashore, between Philadelphia and Atlantic City.

« Western Maryland, between Baltimore and Cumberland, Md. »

Specifications and requirements for automatic train-stop or train-control devices.

The definitions, functions, requirements and specifications governing the installation and operation of automatic train-stop or train-control devices prescribed are given in the appendix as follows :

« *Purpose.*

« The purpose of this general specification is to define automatic train-stop or train-control devices and to outline essential features involved in their design, construction and installation on railroads.

« *Definition of automatic train-stop or train-control devices.*

« A system or installation so arranged that its operation will automatically result in either one or the other or both of the following conditions :

« 1° Automatic train-stop :

The application of the brakes until the train has been brought to a stop.

« 2° Automatic speed control :

« The application of the brakes when the speed of the train exceeds a prescribed rate and continued until the speed has been reduced to a predetermined and prescribed rate.

« *Functions.*

« In prevailing practice the primary function of automatic train-stop or train-control devices is to enforce obedience to the indications of fixed signals; but the feasible operation of essentially similar devices used without working wayside signals may be regarded as a possibility. The following features may be included, separately or in combination, in automatic train-stop or train-control systems :

« 1. Automatic train-stop :

« Without manual control by the engineman, requiring the train to be stoped; after which the apparatus may be restored to normal condition manually and the train permitted to proceed.

« 2. Automatic train control or speed control :

« *a*) Automatic stop, after which a train may proceed under low-speed restriction until the apparatus is automatically restored to normal or clear condition by reason of the removal of the condition which caused the stop operation.

« *b*) Low-speed restriction, automatic brake application under control of the engineman who may, if alert, forestall application at a stop indication point or when entering a danger zone and proceed under the prescribed speed limit, until the apparatus is automatically restored to normal or clear condition by reason of the removal of the condition which caused the low-speed restriction.

« *c*) Medium-speed restriction, requiring the speed of a train to be below a prescribed rate when passing a caution signal or when approaching a stop signal or a danger zone in order to forestall an automatic brake application.

« *d*) Maximum-speed restriction, providing for an automatic brake application if the prescribed maximum speed limit is exceeded at any point.

« *General requirements.*

« 1. An automatic train-stop device shall be effective when the signal admitting the train to the block indicates stop, and so far as possible when that signal

fails to indicate existing danger conditions.

« 2. An automatic train-control or speed-control device shall be effective when the train is not being properly controlled by the engineman.

« 3. An automatic train-stop, train-control or speed-control device shall be operative at braking distance from the stop signal location if signals are not overlapped, or at the stop signal location if an adequate overlap is provided.

« *Design and construction.*

« 1. The automatic train-stop or train-control device shall meet the conditions set forth under general requirements applicable to each installation.

« 2. The apparatus shall be so constructed as to operate in connection with a system of fixed block or interlocking signals, if conditions so require, and so inter-connected with the fixed signal system as to perform its intended function :

« *a*) In event of failure of the engineman to obey the signal indications; and

« *b*) So far as possible, when the signal fails to indicate conditions requiring an application of the brakes.

« 3. The apparatus shall be so constructed that it will, so far as possible, perform its intended function if an essential part fails or is removed, or a break, cross or ground occurs in electric circuits, or in case of a failure of energy.

« 4. The apparatus shall be so constructed as to make indications of the fixed signal depend, so far as possible, upon the operation of the track element of the train-control device.

« 5. The apparatus shall be so constructed that proper operative relation between the parts along the roadway and the parts on the train will be assured under all conditions of speed, weather, wear, oscillation and shock.

« 6. The apparatus shall be so constructed as to prevent the release of the brakes after automatic application until the train has been brought to a stop, or its speed has been reduced to a predetermined rate, or the obstruction or other condition that caused the brake application has been removed.

« 7. The train apparatus shall be so constructed that, when operated, it will make an application of the brakes sufficient to stop the train or control its speed.

« 8. The apparatus shall be so constructed as not to interfere with the application of the brakes by the engineman's brake valve or to impair the efficiency of the air brake system.

« 9. The apparatus shall be so constructed that it may be applied so as to be operative when the engine is running forward or backward.

« 10. The apparatus shall be so constructed that when two or more engines are coupled together, or a pushing or helping engine is used, it can be made operative only on the engine from which the brakes are controlled.

« 11. The apparatus shall be so constructed that it will operate under all weather conditions which permit train movements.

« 12. The apparatus shall be so constructed as to conform to established clearances for equipment and structures.

« 13. The apparatus shall be so constructed and installed that it will not constitute a source of danger to trainmen, other employees or passengers.

« 14. The apparatus shall be so constructed, installed and maintained as to be safe and suitable for service. The quality of materials and workmanship shall conform to this requirement. »

[.625 .232 (.73)]

Illinois Central suburban operation and equipment.

Figs. 1 to 4, pp. 989 to 993.

(*Railway Review.*)

Plans for the development of Chicago's lake front along which the Illinois Central's suburban service is operated will necessitate the complete electrification of this service not later than February 1927, in accordance with the terms of a city ordinance. Terminal electrification in this city has long been a source of argument but this has generally been regarded as a concession to civic development rather than an operating necessity. This applies particularly to the Illinois Central Railroad on which the suburban service is often spoken of as « the best in the world » by its patrons including many who are familiar with suburban service in other large cities. This appraisal of the Illinois Central's steam operated suburban service is all the more remarkable in view of the almost universal dependence placed upon electrically operated multiple unit trains for as large a volume of urban and suburban traffic as handled at Chicago by the Illinois Central Railroad.

The suburban zone of the Illinois Central Railroad includes 38 1/2 miles of line extending from the central business district, south through the residential district along the lake front. One line then branches to South Chicago and another branch extends to Blue Island, while the service along the main line of the Illinois Central extends as far south as Matteson, a distance of 28 miles from the downtown terminal. Connection with an electric line to Gary and South Bend, Ind., is made at Kensington, and a few suburban trains are run west over the Wisconsin division, branching from the main line just south of the Central Station at Twelfth street. The total trackage included in this suburban zone which is to be electrified exceeds 360 miles.

Suburban service on the Illinois Central Railroad at Chicago dates back to the 70's and an early time table shows that in 1881 there were 44 trains operated on weekdays between Central Depot (which was then located at the Foot of Randolph street) and Grand Crossing (8 1/2 miles). Sixteen of these trains ran as far as Kensington (15 miles), which marked the limit of the suburban zone at that time. During the World's Fair in 1893 this service received its first large impetus when facilities were enlarged to handle traffic to and from the fair grounds which were adjacent to the main line between the present Fifty-seventh and Sixty-seventh street stations. Since 1905 the growth of this suburban service is shown by the following tabulation of revenue passengers carried :

Illinois Central Railroad Chicago suburban service : Approximate number of revenue passengers.

1905	13 100 000
1906	13 800 000
1907	13 600 000
1908	11 950 000
1909	12 150 000
1910	13 750 000
1911	13 335 000
1912	13 750 000
1913	13 550 000
1914	12 750 000

1915	13 150 000
1916	14 100 000
1917	13 700 000
1918	12 850 000
1919	15 250 000
1920	19 000 000

In November 1920, an investigation of the daily revenue passenger movement was made in connection with its other studies preliminary to formulating plans for the electrification of the Illinois Central Railroad suburban service. The results of this investigation are summarized in an accompanying table which gives the average weekly business determined by taking 3.67 % of the monthly total. Subsequent investigation indicated that the maximum daily business is 111.3 % and that the average Sunday business is 32 % of the average weekly business. In January of the current year a count of all suburban passengers, which includes approximately 10 000 non-revenue employees of the Illinois Central Railroad daily, showed that there was a total of 2 017 807 passengers carried during that month. The minimum number of passengers handled during week-days was 71 699, and the maximum number in a single week-day was 82 580 passengers.

Of the 70 000 suburban passengers carried on busy weekdays, about 40 000 are handled between 6 and 9 o'clock in the morning and between 3 and 5:30 p. m. A count made recently of passengers leaving from Randolph and Van Buren street stations between 3 and 5:30 p. m. showed 10 714 from Randolph and 7 807 from Van Buren, or a total of 18 522 passengers, an average of 124 per minute, the peak being 3 800 in 15 minutes from 4.30 to 4.45 p. m. or 253 per minute.

The present schedules for suburban trains on the Illinois Central Railroad call for 143 133 train miles in a 30-day month. The weekday service covers a period of 21 hours and 15 minutes, commencing at 3:30 a. m. and terminating at 12.45 a. m. During this interval 348 trains are scheduled, or an average of one train every 7 1/2 minutes in each direction. During the evening rush these trains are operated out of Van Buren street station and through the yards on less than two minutes' headway. South of Twelfth street trains are run over the southbound express track on a three-minute headway. A three-minute headway is also maintained over the northbound express tracks during the morning rush hours.

The real magnitude of the problem involved in the sucessful operation of this heavy suburban service cannot be fully appreciated, however, without taking into consideration the limited terminal facilities at the north end of the system and a very definite restriction which steam operation places upon the practicable length of trains as contrasted with the multiple unit operation of electric trains. The northern terminus of this system is at Randolph street where the passenger tracks are located between Grant Park on the west and freight yards of the Illinois Central Railroad and Michigan Central Railroad on the east, extending over to the lake front. As storage tracks must be provided for suburban equipment between the rush hours, the space available for the operation of suburban trains in and out of this terminal is very cramped.

The operation of this service is further complicated by the movement of light locomotives to the Twenty-sixth street locomotive terminal. The cinder pit and coaling facilities at Randolph street are limited in capacity and as a few of the locomotives in service are of the eight wheel type which cannot safely be run backwards in regular train service, these must be moved to the turntable at Twenty-sixth street each trip. Recently, however, the congestion at Randolph street has been relieved by dispatching some suburban express trains from Van Bu-

Average Density of Week-Day Suburban Traffic		
Randolph St.	Van Buren St	20378
Van Buren St	Central Station	56106
Central Station	16th Street	61907
16th. Street	22nd Street	61968
22nd. Street	26th. Street	62455
26th. Street	31st Street	63442
31st. Street	Douglas	63436
Douglas	Oakland	63002
Oakland	43rd Street	62766
43rd. Street	Kenwood	60787
Kenwood	Hyde Park	57598
Hyde Park	57th. Street	57748
57th. Street	60th. Street	42188
60th. Street	Woodlawn	39900
Woodlawn	67th Street	40519
67th. Street	South Chicago Br.	35080
South Chicago Br.	Brookdale	19858
Brookdale	Essex	19600
Essex	Grand Crossing	19093
Grand Crossing	Avalon Park	18219
Avalon Park	Woodruff	17962
Woodruff	Dauphine Park	17998
Dauphine Park	Burnside	16660
Burnside	103rd. Street	15096
103rd. Street	Pullman	14912
Pullman	Kensington	13529
Kensington	Blue Island Branch	9240
Blue Island Branch	Wildwood	6367
Wildwood	Riverdale	6077
Riverdale	147th Street	5405
147th. Street	Harvey	5023
Harvey	Hazel Crest	1895
Hazel Crest	Homewood	1347
Homewood	Flossmoor	368
Flossmoor	Olympia	165
Olympia	Matteson	128

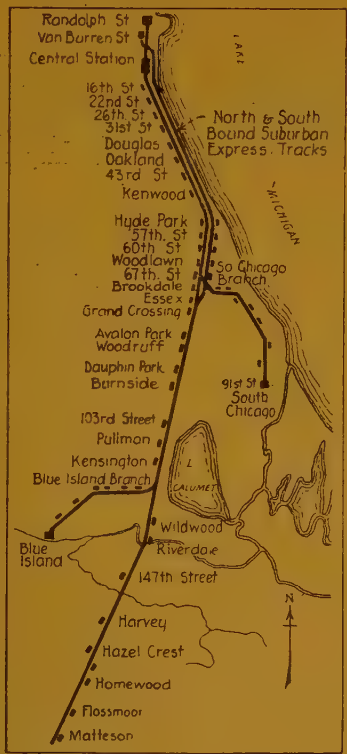
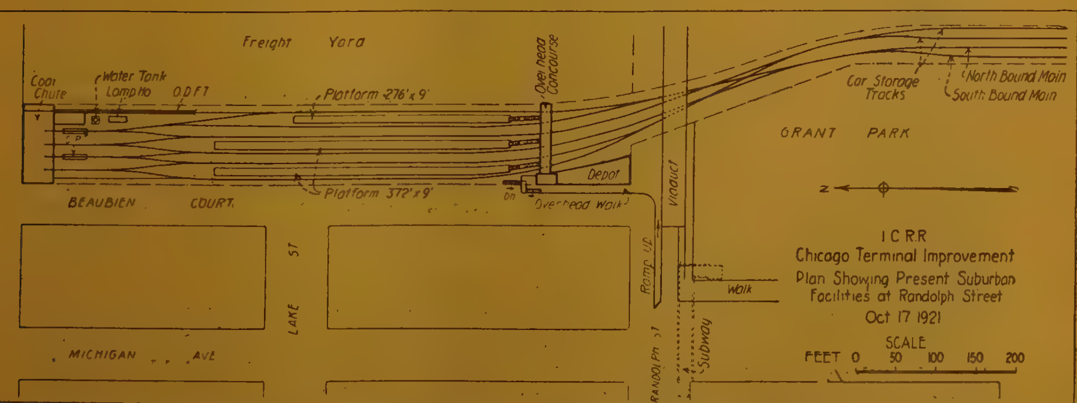


Fig. 1. — Illinois Central Railroad. — Suburban traffic zone at Chicago and analysis of revenue traffic density.



2. — Illinois Central Railroad. — Suburban station at Randolph Street, Chicago, showing track facilities for main ne trains and movements to and from storage tracks. The subway under Michigan Avenue which borders the owntown business district, will eventually lead directly to the new station facilities to be erected when the electri-cation of this service is effected.

ren street station during the rush hours. Trains are made up in a storage yard below this station and backed into a stub track at the south end of the platform at intervals of from six to twenty minutes.

Some conception of the density of this train movement is afforded by a statement that the train frequency during rush hours is such that it is necessary to have switchmen on the ground to operate several of the cross-over switches between the Randolph street station and Central stations, and trains are required to come to a stop before proceeding over the crossovers. South of the Central station, the main line comprises eight tracks as far south as Sixty-seventh street. Two of these tracks are used exclusively by suburban express trains and two by suburban locals and switching to industries on the west side of the right of way. The remaining tracks are assigned to freight and passenger servive entering Chicago over the Illinois Central, Michigan Central and Big Four railroads. Through passenger trains enter the Central station at Twelfth street and make several stops at suburban stations where the platforms are arranged to serve six tracks. The suburban platforms at these stations are elevated to the height of the car platforms.

An unusual situation which adds appreciably to the difficulty of maintaining satisfactory suburban service out of Randolph street and Van Buren street stations during the rush hours lies in the location of these stations with respect to Michigan boulevard. The irregular arrival of suburban passengers from the business and shopping district due to the heavy stream of traffic constantly passing on this boulevard makes it practically impossible to secure uniform loading of outbound trains and if the foot traffic across Michigan boulevard is held up a few more seconds than usual this results in crowding some trains more than others.

Although a subway has recently been constructed underneath Michigan boulevard at Randolph street this has not improved the situation as most people object to using the stairs in and out of the subway and prefer to wait for the traffic to be held in order to cross the boulevard. In fact, the purpose of this subway has been generally misunderstood since it makes no direct connection with the present station. This subway is intended to be an integral part of the new terminal structure included in the electrification program and when this is complete, the subway will lead directly into the station. Its construction in advance of other terminal improvements was undertaken because it was thought that it would tend to relieve the present situation as described and also because the Illinois Central Railroad desired to proceed immediately upon some part of its terminal improvement program as evidence of its intention to execute this extensive terminal improvement in accordance with the spirit of the ordinance enacted by the city of Chicago.

Having described the character of suburban service on the Illinois Central Railroad and the conditions under which service is conducted, consideration should now be given to those elements in the operation of the service that are chiefly responsible for the highly successful character of this operation. In any suburban service the features most essential to success may be listed in the order of their importance, as follows: First, reliability. This is maintenance of train schedules under all conditions that may reasonably be anticipated throughout the year. Suburban service that is subject to habitual delays or periodic breakdowns invariably exercises a damning effect upon the communities dependent on this service. Second, speed, in relation to the time it requires a commuter to travel from his home to

his office. The most universal question relating to suburban communities is « how long does it take to get there ? » Third, frequency of train service. This is an important consideration not only with respect to service during the rush hours but to the interval between trains available for shopping throughout the day or for the theater at night. Fourth, comfort. This applies to the available seating capacity as well as to the character of the car equipment as a suburban service that always fails to provide seats for a portion of it spatrons is never popular.

Applying the first criterion of good suburban service to the Illinois Central Railroad it is noted that the percentage of trains on time is phenomenally high. During the past month it is reported that 99.8 % of all suburban trains were operated on time. The most important factor contributing to reliability of service undoubtedly lies in the condition of equipment and the absence of locomotive failures. No locomotives on the Illinois Central Railroad are subject to a more rigid daily inspection for mechanical defects than the small suburban locomotives employed in this service. Inspection of cars is just as thorough and particular attention is given to the brake equipment. When steam trains are being dispatched at intervals of less than two minutes, the importance of having all brakes in good working order can be readily appreciated. Moreover, the ability to maintain a fast suburban schedule and at the same time make smooth stops is also contingent upon the absence of any mechanical defects.

Good coal is another factor upon which dependence is placed for reliability in this suburban service. A high-grade screened lump coal is provided for this service not only on account of the exacting character of the service, but because of the strict enforcement of smoke ordinances in the city of Chicago. While the reliability of steam suburban service is contingent upon many small details that do not enter into electric operation, it should be borne in mind that a failure in steam operation seldom affects more than one unit, whereas a power plant or transmission line failure with electric operation may cripple the entire service.

Since speed in suburban service is usually considered in conjunction with the time which it requires a commuter to travel from his home to his office, it is pertinent to call attention to the location of the Illinois Central Railroad suburban terminals, which are within a short walking distance of all of the principal office buildings, department stores and theaters. Another element contributing to the popularity of this service from this standpoint is the unbroken express run from the Van Buren street station to Hyde Park station, a distance of 5 1/2 miles, which is covered in ten minutes. This is, strictly speaking, an urban service superior to electric operation under similar conditions in any city. The minimum running time of express trains to South Chicago, a distance of thirteen miles, is 35 minutes, including eight stops. To Blue Island, a distance of 18 1/2 miles, the minimum running time is 49 minutes, including eight stops. And to Matteson, a distance of 29 miles, the minimum running time is 57 minutes, including eleven stops.

The minimum time of local trains between Randolph street station and Sixty-seventh street, a distance of 7 1/2 miles, is 30 minutes, including fourteen stops.

Frequency of service in the suburban zone of the Illinois Central may be inferred from the statement that a total of 348 trains are operated each weekday. In this connection a further comparison may be drawn between steam and electric operation as with steam operation the length of each train is practically limited by the tractive capacity of the locomotives, whereas the operation of

multiple-unit trains by electricity does not impose this limitation. Therefore, with steam operation, frequency of train operation must, of necessity, be increased in proportion to the volume of traffic where it is not practical to increase the size of locomotives in service. While electrification will increase the capacity of the Illinois Central Railroad suburban service it is doubtful whether it will result in much greater frequency of train movement.

One of the most important factors contributing to the success of the Illinois Central Railroad suburban service is the adequacy of the equipment for handling the volume of traffic encountered during the rush hours and it is interesting to note that officials in charge of this service keep in close touch with the requirements which vary with fluctuations in the traffic from day to day by a special report of the number of cars and the number of passengers carried submitted by the train conductor for each suburban trip. This data is used as a basis for adding or with-drawing trains from the schedules as these are revised, or for determining the number of cars required to insure adequate seating capacity. The Illinois Central Railroad probably provides more ample seating capacity for the number of passengers carried than any electrically operated service in this country handling urban and suburban traffic of equal or greater density.

Having dealt specifically with the principal elements contributing to the successful operation of this suburban service, it is important to emphasize the fact that none of these factors would be effective without intimate supervision over every important detail of this service. The operation of all passenger trains within the terminal zone is under the direction of a passenger terminal superintendent and a trainmaster with headquarters at the Randolph street station. The rigid supervision maintained over the condition of equipment in this service has already been commented upon.

Indirect, but no less effective as an element of supervision, is the daily presence of the general officers of the Illinois Central Railroad, practically all of whom from President Markham down, patronize this service. It is certain that no single factor will do more to keep any class of railroad service toned up than frequent patronage of this service by the general officers upon the same basis that this service is offered to the travelling public.

The equipment required to handle the Illinois Central Railroad suburban service comprises 57 locomotives and 227 cars. A few of these locomotives which were taken from main line service are of the eight wheel type, but most of this power is designed specifically for suburban service and adapted to running in either direction. Four locomotives were recently constructed for this service. These locomotives are somewhat heavier than the older suburban power and were designed for handling the new steel equipment during the several years that will intervene before the work of electrification can be completed. The lighter suburban locomotives have two pairs of driving wheels 56 1/2 inches in diameter and 16 by 22 inch cylinders.

Including the new steel suburban cars, there are four classes of equipment employed regularly in this service. The original equipment is of wooden construction with 12 cross seats in the center and side seats extending to either end. These cars weigh approximately 40 000 lb. and seat fifty-six passengers. Later, some wooden main line coaches were rebuilt for this service. These cars have the same seating arrangement but accommodate sixty-two passengers and weigh approximately 51 000 lb. Seventeen of the cars in this service are of the side door type, having cross seats

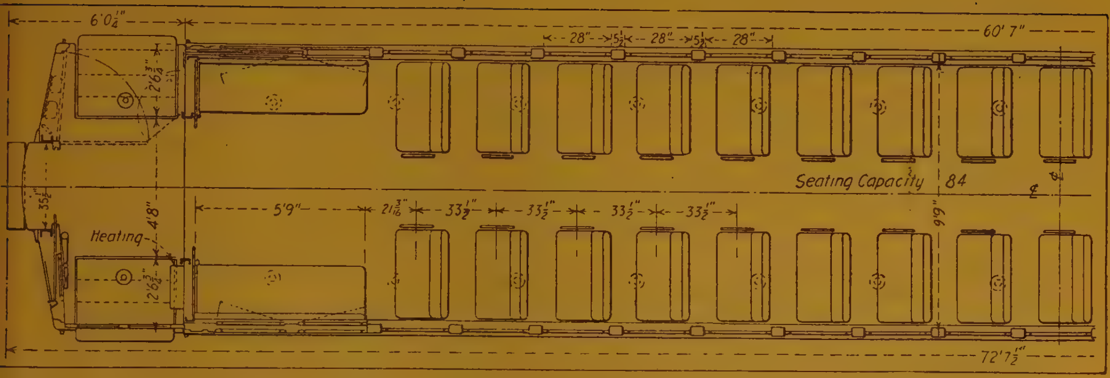


Fig. 3. — Seating arrangement and vestibule dimensions of new Illinois Central Railroad all steel suburban cars.

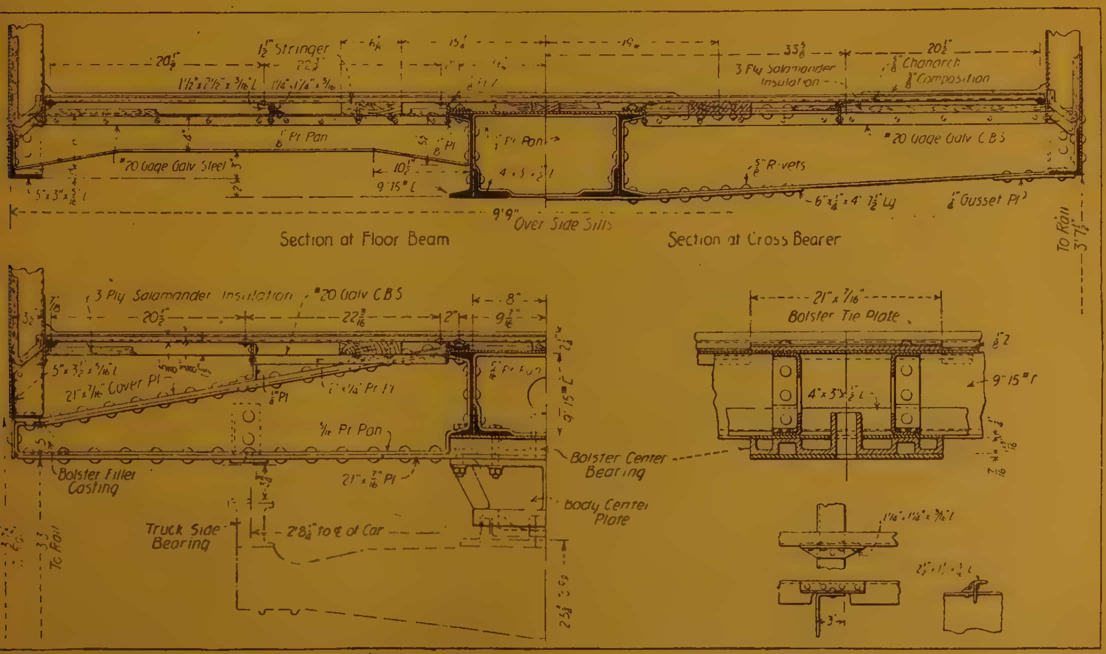


Fig. 4. — Structural details of underframe and body bolster for new Illinois Central Railroad all steel suburban cars.

in the center with an aisle along both sides. These cars can be rapidly loaded and unloaded on account of the side doors which are operated from either end of the car but their use has not been extended as they have not proved popular with the public due largely to the congested seating arrangement and the side doors which make the car difficult to heat evenly in cold weather. These cars seat 100 passengers and weigh 86 000 lb.

Details of the twenty new steel cars which have just been placed in suburban service are illustrated with this article (figs. 3 and 4). These cars seat 84 passengers and weigh 92 100 lb. The seating arrangement was designed to facilitate quick access and departure from the seats as well as to provide for the comfort of the passengers. For this reason, there is ample room between each seat and arm rests are omitted at the end of the seats, while the seats themselves have ample back height for comfort. The width of the aisle is 31 inches between the ends of the seats and 36 inches between the edges of the seat backs. The end doors of the car provide a clear opening of 4 feet and the vestibule trap doors provide an opening of 3 ft. 4 in. in width. The interior finish is steel with the exception of the single sash, which is mahogany. The frame members are practically all of pressed steel with the exception of the longitudinal sills and a few details in the vestibule construction. The cars are mounted on four-wheel trucks with cast steel frames and 33-inch rolled steel wheels on axles with 5 by 9 inch journals.

The vestibule doors are pneumatically operated with air from a reservoir located at each end of the car. These reservoirs are charged directly from the locomotive at main reservoir pressure and have sufficient capacity to provide for the operation of the doors some time after the locomotive has been cut off. The operation of these doors is electrically controlled and the switches for this purpose are located in cast iron boxes mounted on the outer faces of the vestibule door posts at each end of the car so that a brakeman standing at the door of one vestibule can open and close the doors at both ends of two cars. Thus two men can control the operation of all doors on a four-car train which, at present, is the maximum number of these cars operated in a single train. An electric starting signal apparatus is provided with these new cars, as the air signal line is not used in this suburban service. Locomotives assigned for operation with this equipment are to be provided with a small green electric light mounted in the cab, and this is connected with a series circuit carried back through the train by electric connectors between each car. This circuit is connected with each door so that the circuit is broken when the door is open. Energy for this circuit is supplied by the headlight generator on the locomotive, and when in operation the cab lamp is illuminated when all the vestibule doors throughout the train are closed. This serves as a starting signal following station stops.

These cars, as has been stated, mark the first step toward the electrification of suburban equipment on the Illinois Central Railroad, but their immediate construction was actually necessitated by the rapid growth in this suburban traffic. It is stated that every car assigned to suburban operation is now required for actual service during a part of every weekday. The necessity for this new equipment is therefore apparent, and under the circumstances the construction of a car which would meet the requirements of electric operation was the most obvious step. These cars are designed so that they may continue to operate as trailers or may be converted into motor units.

MISCELLANEOUS INFORMATION

[656 .259]

1. — The Teloc locomotive speed-indicator and recorder.

Figs. 1 to 27, pp. 996 to 1001.

(*Engineering.*)

Some years ago we illustrated a locomotive speed indicator, since adopted on a considerable scale, which was made by the Hasler Telegraph Works, of 26, Victoria-street, S.W. 1. The instrument was known as the Hasler speed indicator, and the records made by it were curves drawn to a time base. In order to meet the requirements of railways wishing to have records on a distance base, the Hasler company has now produced another instrument which has been designated the Teloc speed indicator. This later apparatus is illustrated by figures 1 to 27, these illustrations showing the most recent model embodying several important modifications in details of design.

It may be pointed out that among other advantages a record on a distance base is always the same length for a section of line whether travelled over at fast or low speed. No paper is used during stops, and all records can be directly compared with and checked by a standard profile diagram so that the exact speed on gradients and curves, and over culverts, bridges, etc., can be at once read off. Such checking of special speed restrictions can be promptly made by means of a transparency which can be laid over the record.

In the recent model which we illustrate, the record is made on two sections of a continuous paper; a third section is used if a record is taken of brake pressures. This third record is taken by a mechanism which is incorporated in one of the standard forms of the instrument, but which in no wise affects the speed-indicating gear with which we propose to deal more particularly. The instrument may conveniently be dealt with in four main sections, all of which are related to one another. In the first place there is an ordinary clock movement which gives the actual time. This is combined with gear producing a time record. There is also a distance counter, and, lastly, the speed-recording gear. These various components give the following information : the clock indicates the time, and gives a time record on the paper showing the time of day in hours and minutes, the time the engine is at work, and the duration of stops; by means of the speed-recording gear a speed curve is obtained which can be read off directly by scale; and by means of the counter the total accumulated mileage or kilometrage, and the mileage of the last or uncompleted journey can be obtained.

A general view of the instrument is shown in figure 1, while figure 2 shows it with the front removed. Figures 3, 4 and 5 show respectively a corner view, side and back views. The other figures illustrate parts to which we shall refer in detail as we proceed, while a section of a record is reproduced in figure 6. From the latter it will be seen that the record is kept in two sections, as already stated, the upper one being a time record and the lower one a speed curve. Before going into the details of the recording mechanism it will be well to draw attention to the paper drive. The reels are well shown in the back view (fig. 5), and the actual drive in figures 2, 3 and 4. The drive is effected by means of the spiked roller at the upper left-hand corner of the instrument. This is driven through gears from a light vertical spindle, the latter being driven by worm gears to be seen at its lower extremity. The driving worm can be

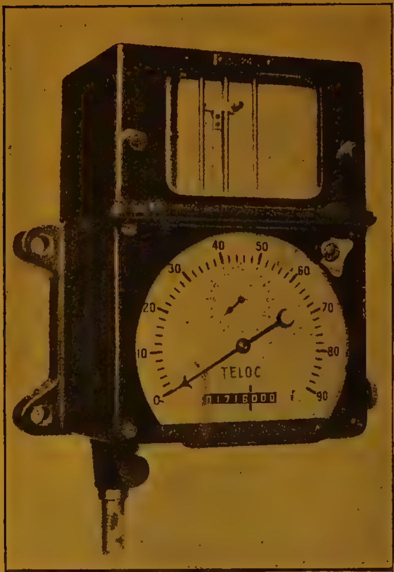


Fig. 1.

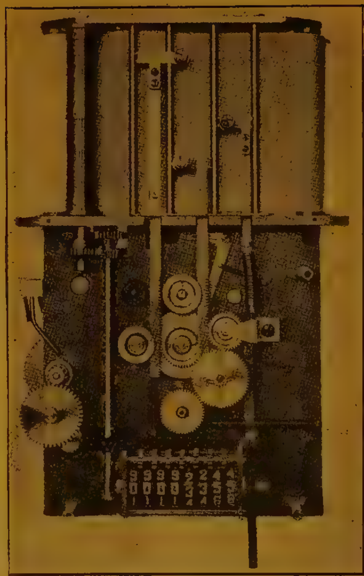


Fig. 2.

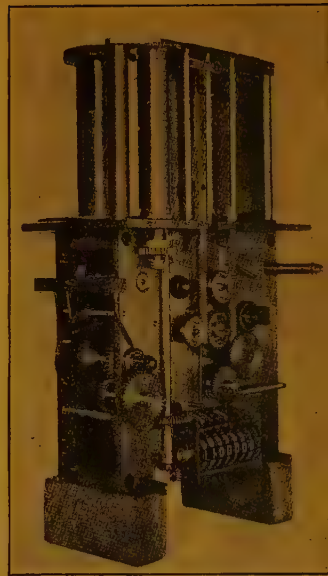


Fig. 3.

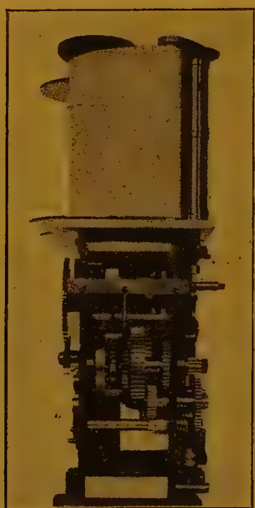


Fig. 4.

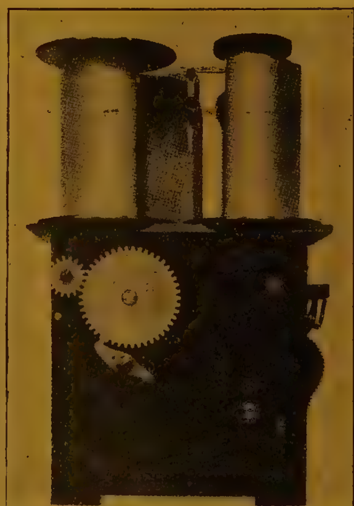


Fig. 5.

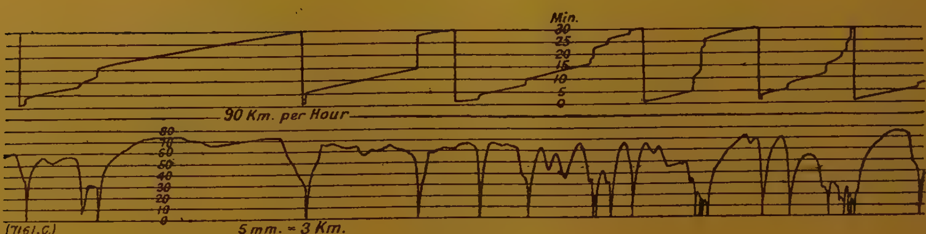


Fig. 6.

identified in figure 4, on the lowest spindle extending between the frames. This is driven through an intermediate spindle by the one about half-way up the mechanism carrying a large toothed wheel. The latter spindle is driven from the main transmission shaft from the engine wheel, and to which we shall refer later. The paper is drawn off the plain reel (to the left in figure 5), round a guide, across the front of the instrument from right to left. After passing the spiked driver, it passes round another guide to the receiving reel behind. This is provided with driving gear and spring tension arrangement in the body of the reel. The paper is held by the friction of a cylindrical clip, of which the knurled head, well seen in figure 5, forms part. Included in the drive between the spindle and the spiked roller, is a ratchet arrangement so that this roller can overrun the driving mechanism, for the purpose of feeding in a new roll, or drawing one off. The punctures produced by the small spikes automatically mark off on the paper the necessary distance units, miles or kilometres, according to the instrument. The paper feed is reduced to 10 mm. per kilometre or mile for instruments indicating up to 50 km. or miles per hour, and 5 mm. for instruments giving a higher speed indication than 50 km. or miles.

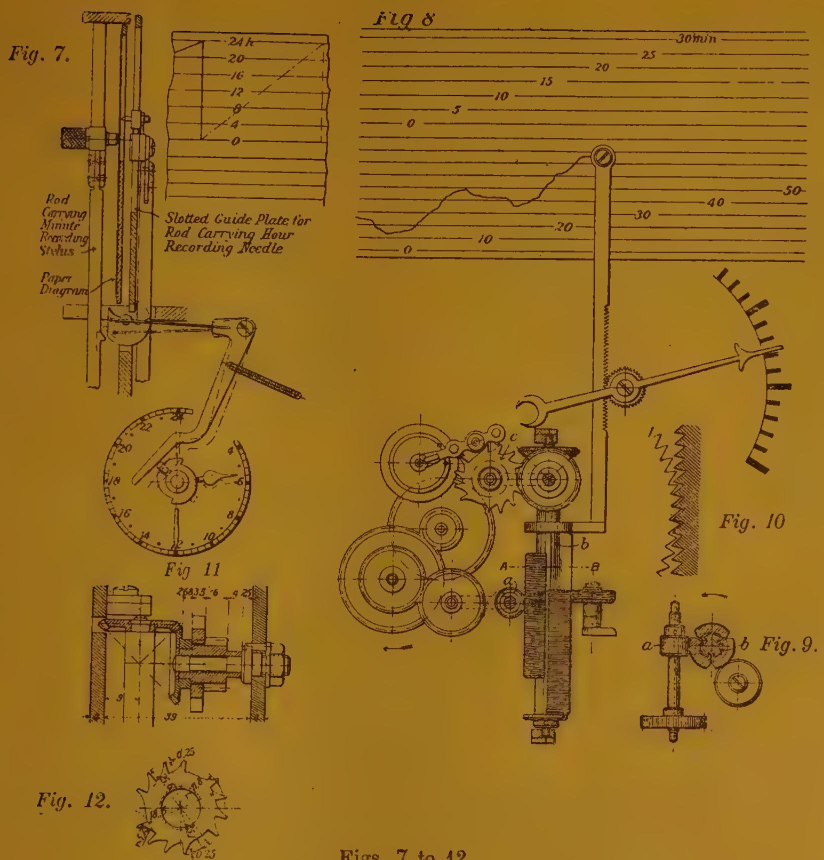
Returning now to the time record, the clock mechanism is of the usual escapement type and requires no description. With its recording pointers it is independent of the rest of the instrument. Reference to the record (fig. 6) will show that the time portion of the roll is divided by horizontal lines marked for 5-minute intervals, the highest being 30 minutes. The pointer marking the minute curve travels across this width of paper in half an hour, then falling back to zero and repeating the process. In conjunction with the minute record another device punctures the paper from the back at hourly intervals, thus identifying the two sections of the minute curve, as one has the hour puncture with it, while the other half hour curve has no hour puncture. The rod and pointer for the minute curve is the one to the left in figure 2. This is operated by a pinion and rack from the clock mechanism. Keyed to the minute spindle is a ratchet plate with two detents. A pawl, fixed to a disc which is carried at the back of the rack-driving pinion, engages with this ratchet plate, and in this manner the rack is lifted. At a certain point, however, when the rack is at the top of its stroke, the pawl is tripped by a fixed pin with which its tail comes in contact. The pinion is then released and the rack is free to drop to the bottom, being pulled down to this position by a light spiral spring (fig. 2). There being two detents on the ratchet plate the pointer returns to zero twice in the hour. This ratchet plate with its two detents is shown in the diagram, figure 7.

The hourly punctures are made from the back of the paper by a sliding pin in a movable frame. The drive, in the same way as described for the minute curve, raises a pricker by means of a pinion and rack. This mechanism is inside the machine and cannot be seen in the photographs. The pricker and rack rod, however, are shown in figure 7. The head of this rod slides in a vertical slot in the guide plate, which is seen again in figure 5, between the reels. The puncture is caused by the guide plate, which is hinged at one side, being knocked forward by a striker shown in figure 7. In this figure for clearness of description the clock face and crank lever shown have been turned through 90 degrees. The striker is pivoted, and when the end of the hour is approaching, is held by the spring and crank lever in the dotted position, the lower arm of the crank lever resting (as shown dotted) close in to the main spindle. When in this position the outer lip of the striker projects so as to foul a lug on the minute indicator rod, and the latter when falling after tripping, kicks up the striker and knocks in the frame and pricker. As the minute hand falls twice per hour, but the hourly puncture is only required once, the striker is arranged so that it can be withdrawn clear of the falling lug when the minute rod drops at the half hour. This is effected by the pin shown on the main spindle pushing out the crank lever into the position indicated in full lines, which results in swinging up the striker out of the way. The crank lever is recognisable in figure 2. To return the hour

pricker to the zero position at the end of 24 hours, a pawl trip exactly similar to that described above for the minute rod, is included in the drive, the only difference being that in this case one detent only is needed, as the pawl has to be tripped once only in the 24-hour round of the clock. The clock can be wound to run for 36 hours. The hour puncture is arranged 5 mm. to the left of the corresponding point on the minute curve. The hour of 12 noon is shown in the middle of the record, and 12 midnight at the top, when the pointer falls to recommence again from the bottom.

Coming next to the speed indicator and recorder, the essential mechanism of this part of the instrument is represented in figures 8 to 26. The speed measurement is based on the principle we described some time ago in connection with the Hasler indicator, but is worked out in a much neater manner. This method does not give an exact indication of the actual momentary speed, but records the speed at 1-second intervals, which is sufficiently frequent to furnish an accurate record. The mechanism embodies a revolving shaft driven at a definite intermittent speed controlled by an escapement. On this vertical shaft are three sliding sectors, figure 9. These are raised while, in turn, each is in contact with the driving mechanism, a height proportional to the speed of the locomotive. A cap, figure 13, rests over the sectors and is thus also raised. To this cap is fixed a rack, figure 13, sliding in a guide seen in the lower part of figure 5. This rack drives a pinion which is connected with gears on the front of the instrument, and these control the height of the middle rod and needle (fig. 2). In the diagram, figure 8, the rod for the sake of simplicity is shown attached directly to the cap. The roller *a* is coupled through gears and bevels to the main spindle drive from the engine wheel, and therefore revolves at a speed proportional to the engine speed. This roller is cut with fine teeth, and these, as shown to a magnified scale in figure 10, mesh with a corresponding thread cut on the outside of the sectors or measuring bars. As the latter are revolved on the shaft *b*, starting from the bottom, each is raised through a height dependant upon the engine speed, as explained, while in contact with the roller. At the end of 120 degrees movement, however, the bar leaves contact with this roller, but is now under the control of a detention device, which holds the bar up while it is revolved through another 120 degrees, when it is released to fall to the bottom ready to be worked up again when next brought into contact with *a*. The sequence is as follows : 1st second, bar is in contact with roller *a*; 2nd second, bar is held up by detention roller; 3rd second, bar falls to bottom; 4th second is the same as No. 1 repeated, and so on. The bars and shaft are shown in figure 13, and in detail in figures 14 to 19. The cap, figures 13 and 14, is fitted with ball bearings. It is supported by whichever bar is highest. In order to take up for any slight wear, and maintain perfect contact between the roller and toothed sectors, the roller spindle is, at the back, carried in a pivoted centre visible at the righthand side low down in figure 5. The detention device is shown in figures 20 to 22. It is held up to the sectors by a spring. The gears shown to the left in figure 8 are offset, but the dotted lines show which are upon the same axis.

The drive of the revolving vertical shaft, figures 8 and 11, is from the first motion spindle which is driven by the bevel *d*, from the engine, through the device illustrated in figures 23 to 26, which is to be seen in position in figures 8 and 9. The speed of the vertical shaft is regulated by the escapement and wheel *c* (fig. 8). Interposed between the positive engine drive and the escapement is a friction drive. The bevel *d* (figs. 24 and 25) is driven by the engine, and the toothed wheel *e*, through other gears, drives the roller which lifts the measuring bars. The bevel *d* also drives a sleeve which ends, between a disc and a ratchet wheel, in a cam shown in figures 23 and 24. The disc and wheel now referred to are fastened together by screws and distance pieces, and arranged between them are two rockers and compression springs (fig. 23). These springs exert an adjustable pressure on the rockers which grip the cam, thus furnishing a friction drive for the wheel *f*. On the right-hand side of this wheel is a pin,



Figs. 7 to 12.

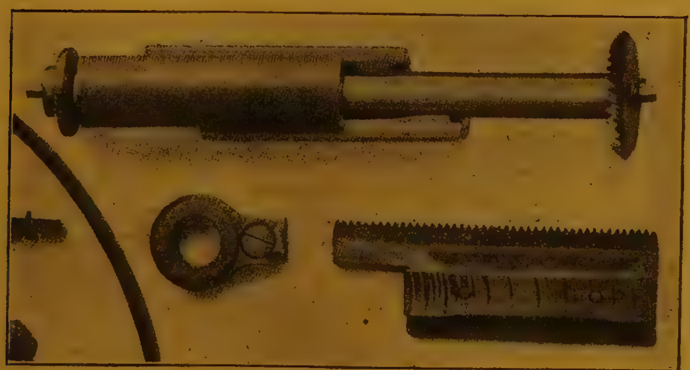
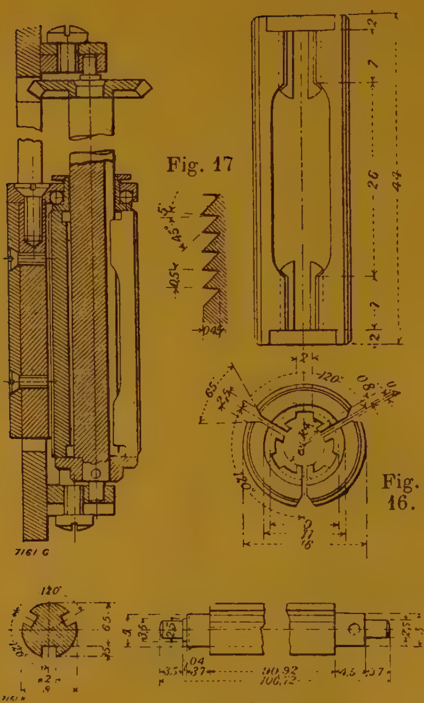
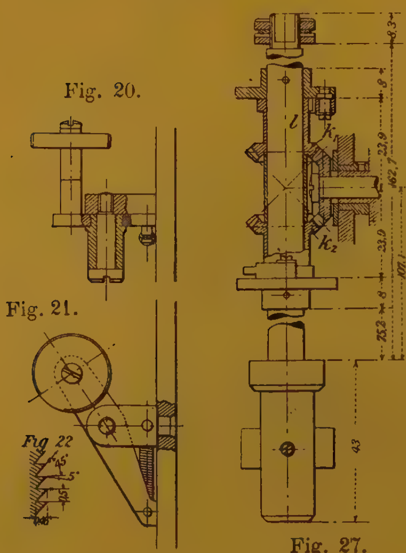


Fig. 13.



Figs. 14 to 19.



Figs. 20 to 22 and 27.

shown again at *g* (fig. 26). This pin engages with a curved lever *i*, spring-controlled (fig. 26), and through this spring tension the broad tooth wheel *h*, also shown in figures 3 and 4, is driven. The wheel *h* through a train of wheels, is connected with the escapement shown in figure 8. The lever *i* floats somewhere between its two extreme positions. When the drive from the spindle is faster than that needed to drive the escapement, the rockers slip on the cam (fig. 23). If the main drive stops the tension exerted by the curved lever and spring suffices to carry on the escapement movement for a short space of time during which all measuring bars return to zero. From figures 8 and 12 it will be noticed that in the escapement wheel every fifth tooth is omitted, making three teeth in the set missing. These teeth are cut out in order that the gear may momentarily quicken up for the time between one sector leaving the roller *a* and the next coming in contact with it. The drive for the speed indicator pointer is through a train of gears from a wheel, held in a triangular-shaped bracket (fig. 2), on a spindle on which is the pinion working the rack of the speed-recording bar.

It is hardly necessary to say much with regard to the counter, which is of the ordinary type, and is driven by bevels from the vertical worm-driven shaft which also feeds the paper (figs. 2 and 3). The three figures to the right can be set by a button to zero at any time, and serve to indicate the day's record, the other figures showing the total. If the instrument as shown in figure 2 is fitted with a recorder for the brake pressure or vacuum, the third stylus (that to the right) is connected with a lever operated by a manometer diaphragm, the underside of which is in connection with the brake pipe. This rod is shown extending down below the instrument in figure 2. No brake record is shown in the diagram (fig. 6), and the gear being an addition which in no way affects the principle on which the speed indicator depends, we need not deal further with it.

One further point remains to be treated, namely, the drive from the engine to the instrument. This varies according to the man-

ner of installation. The drive may be taken off the side rod or an outside crank pin, or, if fitted to coaching stock or a dynamometer car, may be taken from the end of one of the journals. It is transmitted finally to a vertical shaft which runs either way, according to the direction of travel of the vehicle. In order to obtain a drive in one direction only for the instrument, the bevel on the first motion shaft to which attention has already been drawn, is arranged to be driven through one or the other of the bevels k_1 and k_2 (fig. 27), on the ver-

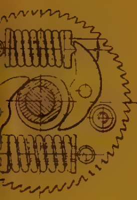


Fig. 23.

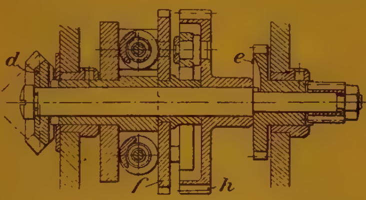


Fig. 24.

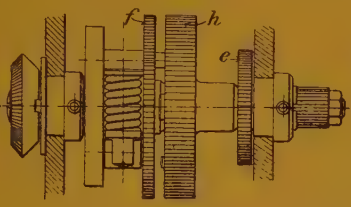


Fig. 25.

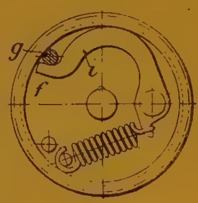


Fig. 26.

tical shaft *l*, which receives its motion direct from the vehicle. These two bevels are driven by discs and pawls, the latter catching in notches in the bosses of the bevels, one being arranged to catch when the vertical shaft is revolving in one direction, and the other engaging in the other direction. In each case the disengaged bevel runs free, and the instrument is driven continuously in one sense. The maximum speed arranged for the driving shaft is 75 r. p. m., so that the speed of the instrument parts is moderate throughout. Only three parts require lubrication other than that given at long intervals of time to clock mechanisms. The oiling of these three parts is arranged for by a small tray with drip pipes; these will be noticed in figures 2 and 3.

[385 .113 (.494)]

2. — Steps taken by the Swiss Federal Railways with a view to re-establishing their financial stability.

In all European countries the railways are at the present time being run at a considerable loss, and everywhere the question is anxiously being asked how much longer will this state of things prevail, and by what means can the financial stability of the railways be re-established.

The management of the Federal Railways concluded their report on the working of the line during the year 1920, with the prediction that after a certain number of years there will again be a surplus in receipts, which will make it possible to gradually wipe out the deficit (1).

The National Advisory Commission of the Federal Railways, on the other hand, has asked the Federal Council to submit to the Chambers, as soon as possible, a report upon « the financial situation of the Federal Railways and the measures contemplated in order to re-establish the balance of profits and expenses, and to cover the existing deficit ».

After having consulted the Management of the Federal Railways, the Federal Council has published the report which it was asked for, and this we propose to analyse. It is of general interest, for the estimates made by the Federal Council, in order to determine the time in which the Federal lines will regain their stability, although hypothetical, as they of course must be, are none the less worthy of

(1) See analysis of « Report of Working of the Federal Railways for 1920 » in the *Revue Génerale des chemins de fer* for October 1921.

attention. They may in fact be useful in similar calculations which the railway managements of other countries, and especially those in France, are making at the present time.

The report of the Federal Council states in the first place that the various factors on which the estimates are based are not as yet sufficiently stable as not to be influenced by passing events. The economic crisis which prevails in Switzerland has produced a falling off in traffic, so that one can no longer count on an annual increase of 5 % which was originally assumed for the passenger traffic or of 4 % for the goods traffic. The Federal Railways did not, in fact, in their calculations, count on any increase in traffic in 1921. They merely hoped for an increase in their takings as a result of the last increase in rates, which only took effect for the last five months of 1920, but which were in force throughout the whole of 1921. For the following years they count on a moderate increase in traffic, as follows :

Year.	Passenger traffic.	Goods traffic.
1922.	2 %	1 %
1923.	3 %	2 %
1924.	4 %	3 %

On the other hand, the Federal Railways believe that they can estimate the results from miscellaneous sources at a somewhat higher figure than that which they took in their 1920 report, because the rents (derived from railway property) have risen since then, and there is a tendency for these to rise still higher in coming years.

The new estimates of increase are consequently as follows :

YEAR.	Transport. receipts.	Miscellaneous receipts.	Total working receipts.
	Francs.	Francs.	Francs.
1921	401 000 000	13 100 000	414 100 000
1922	406 200 000	13 200 000	419 400 000
1923	415 600 000	13 300 000	428 900 000
1924	429 400 000	13 400 000	442 800 000

The Federal Railways believe that these figures are not exagerated, for although the present depression may hinder the increase in receipts to a larger degree than calculated for, it is probable that when this has passed, the development of traffic will be considerably greater than is allowed for in the report.

On account of the uncertainty of the future, the working expenses, as well as the takings, can only be estimated approximately. In 1920, they rose to 346 000 000 fr., only exceeding by a very little the estimated amount of 345 millions 600 000 fr. The facts on which the estimates are based for the years 1921-1924, as far as one can predict, are as follows :

1° The revision which is now being made in *the Federal laws dealing with salaries and the fixing of wages* will entail, according to the forecast, an increase in expenses, unless a considerable fall in prices takes place. Taking as a basis the rules laid down by the Federal Finance Department and with the number of personnel as at 1 April 1921, the additional expense works out at 5 000 000 fr. per annum. This increase will probably begin to be felt in the 1922 accounts. It is not considered that any further liabilities will occur in the following years, because the majority of the employees will have reached their maximum salaries, and future increases in pay will no doubt be compensated by the vacancies caused in the staff from natural causes;

2° The accounts for 1921 allowed for the sum of 4 400 000 fr. for allowances to pensioners to meet the rise in prices. These allowances will cease in the future, as far as concerns the expenses of the traffic department, if the pensions and relief fund have to meet these charges. It will result it is true in an increase in the deficit of the pensions and relief fund, for which the liability of interest and repayment will again devolve upon the Federal Railways;

3° In consequence of the complete observation of the new *law regarding the length of working hours*, the accounts for 1921 anticipated an additional expense for salaries and wages, but owing to the reduction in the staff which the commission of enquiry into the working conditions of the staff consider can be made as regards the stations, the expenses of the traffic department as regards salaries will not increase above the figure calculated before the law regarding the length of working hours was put into force, even in the event of the present day traffic, which is much reduced, again increasing considerably. It is impossible as yet to give actual information as to the economies which will be effected by the measures in question. Putting into practice the principles laid down by the Commission, some simplifications have already been made in the organisation of the districts, but in view of the general trade depression which prevails at the present, it has not been possible to discharge the redundant staff immediately; in most cases the reduction will be effected gradually by natural elimination. However, it is already proved, that by means of the reforms adopted, and in consequence of the falling off in traffic, it would not only be possible in 1921 to fully conform with the new law regarding the length of working hours (granting more days of rest and holidays, reduction of unessential duties and longer rest at night) without increasing the staff, but would still allow a further reduction to be made. Thus, owing to a better organisation in the stations and goods yards, there will be no increase in the cost of the staff of the traffic department, as was at first thought. The surplus expenditure anticipated should thus be reduced in the new estimate. The economies that the projected reforms can effect in these expenses was estimated by the Federal Railways at 7 millions in 1921, at 8 millions in 1922, and at 9 millions for the years 1923 and 1924;

4° An important modification is that which will transfer the payments now made by the Federal Railways Administration to the *pensions and relief fund*. The allowances based on the increased cost of living have been completely included in the guarantee dated 1 October 1920, and the permanent employees of the traffic department and of the workshops will probably be admitted into the fund their admission to date retrospectively from 1 January 1921. The budget for 1921 took into account the liabilities imposed on the insurance scheme, both by the original allowances and by the increased payments dating from 1 April 1921, but not the additional money required for the inclusion of the permanent workmen. The statutary contribution of five twelfths of the total basic allowances was previously estimated at 25 000 000 fr., and a first annual payment of 3 237 600 fr., was therefore included in the budget with the intention of distributing the paying off of this abnormal payment over ten years, the interest being 5 %. The total contribution of the Federal Railways to the pensions and relief fund thus amounted in 1921 to 14 580 000 fr. The new regulations which have been drawn up for the pensions and relief fund will alter appreciably the amount of the contributions. According to this scheme, instead of four twelfths of the increased payments resulting from deductions from the total basic allowances, the staff will only have to pay a small part of this increase. The contributions of the railway administration are also similarly reduced in consequence. They will not amount to more than 8 400 000 fr. in place of 25 000 000 fr., but it should be stated, as in the case of the abolition of the increase cost of living allowances to the pensioners, that this reduction in the contribution will lead to an increase in the funds deficit, which will finally have to be met by the Federal Railway Administration.

The extension of the superannuation scheme to the permanent workmen, which is laid down in the new rules, will also produce an important increase in the deficit. In order to reduce this, it is intended, in striking a balance, to allow interest at 5 % in place of the present 3 1/2 %. The condition preliminary to this measure would be that the Administration of the Federal Railways guarantee this interest to the fund. What then becomes of the deficit if the securities in which the reserve is invested do not yield this interest? Also, in accordance with the rules of the assurance fund of the staff of the Confederation staff, the ordinary contribution of the Federal Railways, amounting to 7 % of the salaries, will be increased, after 1924, at the rate of 1 % per annum, up to 11 %. It is impossible to say as yet to what amount the deficit of the assurance fund will attain under the new rules. Exact calculations will have to be made on this point after these rules have been brought into force. At the moment, the Federal Railways anticipate that they will pay annually, in the ordinary course, 1 million 500 000 fr. as interest on and to reduce the amount of the deficit. When the amount of this new figure has been fixed, it should be arranged to pay it off in a definite time.

As will be seen from the preceding, the contributions of the Federal Railways to the pensions and relief fund constitute a heavy charge on the working expenses. Still greater sacrifices will have to be made in the coming years in consequence of the more generous pensions that are contemplated for the staff. This state of affairs has called forth proposals for decreasing the charges on the Federal Railways, either by partially suspending their contributions to the fund until the present crisis has been surmounted, or by replacing in the superannuation the system of reserve by that of distribution. The Federal Railways are uncertain about adopting these propositions, for the future liabilities will not be modified, and the only result would be a reduction at the present at the expense of the future, and it is not to the interest of the Federal Railways that the future charges should increase excessively. The important reserve which has gradually accumulated in the establishment of the Federal Railways insurance scheme cannot moreover be considered as idle capital. It is legal for the Federal Railways to use the funds available cash for constructional work, provided a receipt is given for the amount deposited, as is already done. Thus, so long as the reserve increases, as will still be the case for a number of years, the annual increase will constitute a very welcome asset to the Federal Railways, to meet the needs of the treasury for the electrification of their lines. This advantage will naturally be of no value until the financial equilibrium of the Federal Railways is again established, and the contributions to the pensions and relief fund can be paid without increasing the debt;

5° The reduction in the price of fuel which has recently taken place will entail an important reduction in the expenses of the motive power department. This economy will, however, only be realised gradually, as there is in hand a large stock of coal (about 700 000 t.) bought as a reserve, but paid for at high prices. In 1920, the average cost of coal was 175 fr. per tonne. For the coming years, the Federal Railways count upon having to pay, on the average 150 fr. per tonne in 1921, 110 fr. in 1922, 90 fr. in 1923, and 80 fr. in 1924. The cost of fuel and of electrical energy was estimated at about 107 400 000 fr. in the 1921 budget, the probable costs for the coming years being less by 25 940 000 fr. in 1921, 41 850 000 fr. in 1922, 47 640 000 fr. in 1923 and 51 670 000 fr. in 1924. The Federal Railways consider that these figures are on the safe side. It does not appear impossible that the fall in price may be still greater and more rapid;

6° Finally, mention should be made of an increase in the expenses brought about by the *Accident Insurance* since 1921. This increase is due to the fact that the maximum salary which comes under the National Swiss Insurance scheme has been raised from 4 000 to 6 000 fr. The Federal Railways estimate this increase as being 250 000 fr. per year.

* * *

Based on the above considerations, the results of working for the years 1921 to 1924 will probably be as follows :

ACCOUNT OF WORKING RECEIPTS AND EXPENDITURE.

—	1921	1922	1923	1924
	Francs.	Francs.	Francs.	Francs.
Working receipts	414 100 000	419 400 000	428 900 000	442 800 000
Working expenses :				
Working expenses according to the 1921 accounts. . .	379 580 000	379 580 000	379 580 000	379 580 000
To or from these expenses must be added or deducted, the following sums, in accordance with the calculations given above :				
1. Additional expenses due to alterations in wages and conditions of employment.	...	+ 5 000 000	+ 5 000 000	+ 5 000 000
2. Increase in cost of living allowances to pensioners, contained in 1921 account .	— 4 400 000	— 4 400 000	— 4 400 000	— 4 400 000
3. Decreased cost of staff . .	— 7 000 000	— 8 000 000	— 9 000 000	— 9 000 000
4. Modifications in the payments to the pensions and relief fund :				
a) Cancellation of all the payments laid down in the 1921 account . .	— 14 580 000	— 14 580 000	— 14 580 000	— 14 580 000
b) Payment, on the other hand of the new contributions for the years 1921 to 1924. . . .	+ 13 760 000	+ 13 310 000	+ 13 800 000	+ 15 810 000
5. Decreased cost of fuel and electrical energy below the sum of 107 400 000 fr. in the 1921 account	— 25 940 000	— 41 850 000	— 47 640 000	— 51 670 000
6. Increased expenses for accident insurance premiums.	+ 250 000	+ 250 000	+ 250 000	+ 250 000
Probable working expenses .	341 670 000	329 310 000	323 010 000	520 990 000
Surplus of receipts over expenses	72 430 000	90 090 000	105 890 000	121 810 000

BALANCE SHEET.

Commencing with the 1921 account, which provides for a deficit of 48 888 290 fr and takes the surplus of receipts over working expenses as 55 851 110 fr., and taking into account the increases or decreases in various expenses, we obtain the following results for the years 1921 to 1924 :

	1921 — Francs.	1922 — Francs.	1923 — Francs.	1924 — Francs.
Deficit in balance sheet for 1921	— 48 890 000	— 48 890 000	— 48 890 000	— 48 890 000
A profit of 55 850 000 fr. from traffic being included in the above sum, this will be increased in accordance with predicted traffic results to .	+ 16 580 000	+ 34 240 000	+ 50 040 000	+ 65 960 000
The interest on capital will increase after 1922 at about 6 000 000 fr. per year, due to increase in capital for construction. This will reduce the result by	...	— 6 000 000	— 12 000 000	— 18 000 000
The sinking fund will also make a smaller demand, owing to the period being extended from 60 to 100 years. The results for 1921 and the following years will thus be increased as follows	+ 10 000 000	+ 10 000 000	+ 10 000 000	+ 10 000 000
The expenditure on renewals should be increased as shown here, in consequence of the increase in train mileage and the expenses of electric traction.	...	— 500 000	— 500 000	— 500 000
The balance will thus be brought up to	— 22 310 000	— 11 150 000	— 1 350 000	+ 8 570 000

According to these figures, if the assumptions on which the calculations are based are approximately realised, a balance between the Federal Railways' receipts and expenses will be obtained at the end of 1924, this year yielding a small surplus of receipts. There is, however, the accumulated deficits of the preceding years. At the end of 1923 the total amount of this will be 225 800 000 fr., from which must be subtracted the surplus for 1924, *i. e.*, 8 570 000 fr.

At the end of 1924, that is to say, when there is again a surplus, the debt will be shown on the balance sheet as 217 230 000 fr.

The Federal law of 16 December 1920, which amends clause 7 dealing with the sinking fund, by increasing the period fixed for paying off the capital from 60 years to 100 years, stipulates that the surplus capital paid off from 1903 to 1919 shall be used to cover part of the debt in 1920. This latter will also be subject to a diminution due to the sum of the

surplus capital paid off up to the end of 1919, which is 98 400 000 fr. The estimated debt, at the end of 1924, will thus amount to 118 830 000 fr.

This sum should be gradually paid off by means of the future surplus receipts.

The report of the Federal Council concludes, that in addition the increase in rates, which has already been brought into force, and amendment of the system for paying off the capital, the reforms in the methods of working and the considerable drop in the price of fuel will also probably improve the financial situation. The new calculations give an indication of what will happen after 1925, the improvement will continue, so that we may count upon a gradual reduction of the debt. It is very much to be hoped that the Federal Railways' estimates are still erring on the pessimistic side and that owing to the general reduction in prices that has commenced, the rates may also be reduced. During the war and the post war period, the rates were raised to such an extent as to hamper the development of traffic, but so long as the balance sheet shows a deficit, there can be no talk of reducing rates on a general scale. One must, for the time being, be content with making certain reductions with a view to fostering traffic, but without running any risk as regards the finances of the Federal Railways.

M. PESCHAUD.

[313 : 385 (.42)]

3. — Statistical returns of railway companies in the United Kingdom.

The British Minister of Transport has published the statistical returns relating to the capital, traffic, receipts, working expenses and operating results of the railway companies in the United Kingdom in 1920. Taking them as a whole, the following results are obtained. In spite of the increase in fares and rates, both passenger and goods traffic show a considerable increase over the returns of the previous year, whilst the expenditure has been much more in proportion to the receipts. In spite of all, however, the net revenue, exclusive of the Government compensation, was £7 411 000 less than that of 1919, the exact sum attained being £9 923 000.

On 31 December 1920, capital invested in railway stock from the beginning reached the sum of £1 418 600 000, and capital expenditure £1 208 200 000, an increase of £5 300 000 on the figures shown in the balance sheet of 31 December 1919. This expenditure is classified as shown in the following table :

—	Total expenditure.	Increase 1920 compared with 1919.
Capital expended upon the railway	1 059 000 000	2 800 000
Horses and road vehicles	1 000 000	200 000
Steamboats and marine workshops	8 300 000	1 800 000
Canals	8 600 000	...
Docks, harbours, and wharves	53 100 000	300 000
Hotels	8 600 000	...
Electric power stations, etc.	6 300 000	100 000
Land, property, etc., not forming part of the railway or stations	43 100 000	...
Other industries	100 000	...
Subscriptions to companies other than railway companies	2 000 000	...
Special items	1 900 000	...
Expenditure not allocated (mainly railway)	16 200 000	100 000
Total	1 208 200 000	5 300 000

The financial results of working the several undertakings may be briefly summarised as follows :

ITEMS OF THE BUDGET.	Gross earnings.	Expenditure.	Increase (+) or decrease (—).
	£	£	£
Railway	248 132 000	241 398 000	+ 6 734 000
Passenger road vehicles	147 000	182 000	— 35 000
Steamboats	4 688 000	4 954 000	— 266 000
Canals	417 000	883 000	— 466 000
Docks, harbours, and wharves	6 373 000	7 276 000	— 903 000
Hotels, refreshment rooms and cars	7 544 000	6 904 000	+ 640 000
Other separate business	113 000	158 000	— 45 000
Total.	267 414 000	261 755 000	+ 5 659 000
Miscellaneous receipts (net)	...	...	+ 4 264 000
Total net earnings	...	...	+ 9 923 000
Add government compensation	46 019 000		...
Less : Estimated value of services rendered to government included above	2 930 000		...
Net government compensation.		. . =	+ 43 089 000
Total net income			+ 53 012 000

In 1919, the excess of earnings over expenditure was £13 386 000 or nearly double the figure relating to the working in 1920; the net earnings were £17 334 000, and the call on the Government guarantee £35 736 000, making a total net revenue of £53 070 000, an increase consequently of £58 000 over that of 1920.

Owing to the continual increase in wages and prices, trade depression, and the miners' strike which took place during the Autumn, the working expenditure exceeded by £74 697 000 that of the previous year.

The appropriation of net income is given in the following table :

Rentals and fixed charges, etc.	£.	2 032 000
Interest and dividends on capital		49 708 000
General reserves, etc (net)		1 264 000
Total.		53 004 000
Increase in amount carried forward		8 000
Total.		53 012 000

The inventory also gives the following items of interest from a composite balance sheet of all companies :

—	Situation on the 31 December 1920.	Increase (+) or decrease (—) compared with 1919.
	£	£
Savings bank deposits	12 200 000	+ 800 000
Superannuation and other provident funds	23 100 000	+ 2 300 000
Depreciation funds	62 900 000	+ 3 600 000
Other reserves shown in balance sheet	15 300 000	+ 1 000 000
Cash on deposit and at bankers, etc.	7 800 000	— 6 300 000
Investments in Government securities	37 100 000	— 9 300 000
Stock of stores and materials	41 000 000	+ 10 600 000
Outstanding traffic accounts	19 100 000	+ 11 700 000

During the year 1920, 89 miles of single track was opened to traffic, increasing the total, including sidings, to 55 338 miles. The total number of locomotives is 25 288, an increase of 217 on the previous year. Goods wagons have increased by 12 074 units to 765 442. Only the passenger coaches, which at 54 317, show a decrease of 505.

Train mileage is given as 378 070 430, an increase of 29 158 600 over the preceding year. The average receipt per train-mile was 120.02 d. for passenger train traffic, and 209.86 d. per route-mile for goods train traffic, against 127.79 (decrease per train-mile of 7.77 d.) and 123.82 (increase of 86.04 d. per route-mile) in 1919, respectively.

The following were the passenger traffic results :

NUMBER OF TICKETS.	1920	1919	Increase (+) or decrease (−).
Ordinary tickets :			
First class	37 675 085	44 647 654	— 6 972 569
Second class	7 488 276	7 005 160	+ 483 116
Third class	1 096 585 156	1 083 458 754	+ 13 126 402
Total	1 141 748 517	1 135 111 568	+ 6 636 949
Workmen's tickets	462 743 131	416 755 044	+ 45 988 087
Season tickets :			
First class	174 946	161 258	+ 13 688
Second class	111 198	102 157	+ 9 041
Third class	751 470	659 953	+ 91 517
Total	1 037 614	923 368	+ 114 246

Goods traffic increased by 13 082 353 tons or 4.2 %; the total tonnage carried, 323 971 117 tons, being distributed as follows :

—	1920	1919	Increase.
	Tons.	Tons.	Tons.
General merchandise	72 613 046	72 545 774	67 272
Coal, coke and patent fuel	182 640 401	181 461 627	1 178 774
Other minerals	68 717 670	56 881 363	11 836 307
Total	323 971 117	310 888 764	13 082 353
	Head.	Head.	Head.
Live stock	21 294 066	21 198 386	95 680

On account of the general rise in the rates, the average receipt per ton increase from 4 s. 4.18 d. in 1919 to 7 s. 10.72 d. in 1920.

M. Peschaud.

[385 .51 (42)]

4 — Railway Council Scheme on British Railways.

By the Railways Act of Great Britain which received Royal Assent on 19 August 1921, there was set up under part IV a Central Wages Board and a National Wages Board which were modifications of Boards that had previously existed. The Central Wages Board consists of eight representatives of the railway companies and eight representatives of the employees. The National Wages Board is comprised of six representatives of the railway companies, six of the Unions, and four representatives of the users of the railways, one nominated by the Trade Union Congress and three by National Trade Organisations, and an independent chairman nominated by the Ministry of Labour. In addition that Act authorised the establishment of railway councils and a committee of six representatives of the companies and six of the Unions, which was set up to define the constitution and function of the councils.

For some considerable time negotiations have been in progress between the companies and the Unions with a view to agreeing on a complete scheme, and one has now been brought out which to the two bodies already dealt with adds three more, so that the arrangement now includes the following five grades of committees :

a) Local Departmental Committees;
b) Sectional Railway Councils;
c) Railway Councils;
d) Central Wages Board;
e) National Wages Board.

These committees are to deal with practically all employees up to and including the grade of station masters, agents, yard masters, traffic controllers, and various engineering foremen, with the exception of shopmen. Although the above grades are included, the majority of those dealt with are employees who are in what have become known as Conciliation Board Grades.

The method of voting for the election of the employees' representatives of the first two of the above committees (*a* and *b*) has been decided upon. The candidates, nominators and voters must be 18 years of age or over, and must have had twelve months continuous service with the company before being qualified to take part in the scheme.

a) Local Departmental Committees.

These are to be established at any station or depot where there are not less than 75 employees of one department or group of grades. The committee shall consist of not more than four representatives of each side, and the employees representatives are to hold office for twelve months after election. The objects of the committees are to form a recognised means of communication between the employees and the local officials of the railway companies, and to give the employees a wider interest in the conditions under which their work is performed. The matters to be discussed are those which concern the employee in his daily work, and those which affect the economical working of the railway in which it is recognised that employees of all classes and grades are interested.

Any matter on which agreement cannot be reached may be referred by either side to the Sectional Railway Councils.

The employee members of these Committees as well as those on the Sectional Council directly above them must be employees of the company. Where there are less than 75 regular employees of a department or group of grades, it is not proposed that they shall be left wholly outside the scheme. The arrangement is that they should appoint representatives to discuss local matters within the scope of the scheme with the company's local officials.

b) Sectional Railway Councils.

There are to be not more than five of these on each railway, and although the term railway is to apply here as with the Railway

Councils to the Amalgamated Companies formed under the Act of 1921, for the time being it is to apply to a railway as at present constituted.

The representation of each side is to be not more than twelve with each Sectional Council, and the representatives of the employees must be employees themselves, but in addition each side is to nominate a secretary from whatever source it pleases who may take part in the proceedings. This allows the men to nominate a Trades Union official to act for them in this capacity, and to sit on the Council.

The Sectional Councils are each to represent groups of grades, and a suggested method of constituting them is as follows :

GROUP OF GRADES.		Numbers of employees.	Allotted numbers of representatives.
No. 1.	a) Station masters, agents, yard masters and traffic controllers	950	2
	b) Clerical staff	7 200	7
	c) Traffic and goods department inspectors and foremen, etc.	1 250	2
	d) Engineering and signal department inspectors and foremen, locomotive, carriage and wagon department inspectors and foremen	480	1
	Total.	9 880	12
No. 2.	a) Engine drivers, firemen and cleaners	12 200	10
	b) Electric train motormen	...	...
	c) Shedmen and hydraulic men	2 100	2
	Total.	14 300	12
No. 3.	a) Signalmen, etc.	4 300	3
	b) Guards and shunters, etc.	6 700	4
	c) General porters, parcel staff, etc.	5 400	3
	d) Carriage and wagon examiners, carriage cleaners, electric light men, etc.	2 000	2
	Total.	18 400	12
No. 4.	a) Goods shed and yard staff	5 300	8
	b) Cartage staff	2 100	4
	Total.	7 400	12
No. 5.	a) Gangers, sub-gangers, and undermen	8 100	9
	b) Signal and telegraph linemen, etc.	1 700	3
	Total.	9 800	12

For election purposes a railway may be split into not more than five districts. The election of representatives are to be carried out jointly by nominees of the Trades Unions and of the

Railway. One third of the representatives shall retire each year, and when the scheme comes into full operation the term of office of a representative will be three years, but he will be eligible for re-election.

The duties of the Sectional Councils are to arrange for the local application of awards made by the National Agreements to the particular railway; to consider suggestions as to operating, working, etc., to deal with other matters in which the company and its employees are mutually interested, and any subjects remitted to them by the main Railway Council.

Railway Councils.

These are to be made up of ten on each side, the employees' side consisting of two from each Sectional Council elected by that Council.

The duties of the full Railway Council is to consider any subjects which it is open to a Sectional Council to deal with, and which is of common interest to the staff of two or more sections, and any subject referred to it by a Sectional Council, providing that before any subject is considered the Sectional Councils concerned have been given an opportunity of considering it.

There are several points in common to the Sectional Councils and the Railway Council which may be mentioned. In each case both sides nominate one of their members as chairman of their side, and when a decision is reached — which must be by agreement between the two sides — this is to be signed by the two chairmen and two secretaries. After this it shall be printed and posted so as to be accessible for the information of the employees concerned.

Meetings of all Councils shall be held at least twice per annum, and at such other times as may be necessary by arrangement between the secretaries. Any difference between the secretaries as to whether matters come within the scope of the scheme may be submitted by the Trades Unions to the railway companies or *vice versa*, and if agreement is not then reached, it may be referred to the Central Wages Board.

These are the main points of the agreement arrived at between the British railway companies and the Railway Trades Unions, and they must be looked upon as a great advance on previous arrangements, and the operation of the scheme will be watched with interest. It will be appreciated that the Local Departmental Committees should clear up many of these personal grievances which oftentimes interfere with the smooth working of an establishment, whilst the Councils deal with the broader points which arise.

The arrangement was that the Local Departmental Committee and the Sectional Councils should come into existence on 3 April, the Railway Councils being left over for the present.

It has also been agreed that a revision be made in the rules governing the procedure with regard to discipline. It has been arranged that an employee had the right of appeal against punishment and also the right to be accompanied by an advocate, and to call witnesses, and this is to be done *before* and not *after* the final decision as to punishment has been made.

H. F.

[385 .52 (42) & 385 .581 (.42)]

5. — The National Wages Board Award to Scottish Railwaymen, and its subsequent application on English Railways.

On 24 January last, the award of the National Wages Board on the application for modification of existing conditions made by the Scottish railway companies was made. The Board was constituted, according to agreement, *viz.*, an independant chairman, six

representatives of the railway companies, six representatives of Trade Unions (in this case two each from three Unions) and four representatives of users of Railways.

The application was from all five of the Scottish railways, who were represented by Mr. D. A. Matheson, the general manager of the Caledonian Railway. The Union concerned was the National Union of Railwaymen, whose representative was Mr. C. T. Cramp, one of their secretaries.

The claims of the railway companies were :

1° That wages should be reduced by the increases granted under the Award of the National Wages Board of June 1920. This Award granted increases of from 2 sh., to 8 sh. 6 d. per week, the average amount being about 5 sh. per week;

2° That night duty should not be specially paid for;

3° That junior employees should not be paid the adult rates until they attain the age of 21 years instead of 18 years as previously agreed upon;

4° That the working day of 8 hours should be modified. The general application was that this should be increased to 10 hours for engine and shed staff, carriage & wagon examiners and greasers, signalmen, shunters, except in first class yards; guards, both passenger & goods, and travelling ticket collectors, other traffic grades, and all grades of the Goods Department. Certain exceptions were suggested should remain at 8 hours, where the work was continuous and arduous.

In the Engineering Department 9 1/2 hours on weekdays other than Saturday, and 5 1/2 hours on that day (53 hours per week) were proposed with certain exceptions.

In several of the above cases it was proposed that the day's work might be « spread over » a period of from 1 1/2 to 2 hours more than the hours stated. This was looked upon as a very essential point especially on parts of the line where the traffic is light. Frequently at such places the work is very intermittent, and the necessity of not working men more than a period of 9 or 9 1/2 hours from start to finish has been felt to be in every respect uneconomical. The « spread over » would allow of the men being booked off when not required, as long as the period from their commencing work until they finally finished the shift did not exceed the specified time — in the cases quoted of from 11 1/2 or 12 hours.

It was also proposed that the hours of crossing keepers, not resident at their crossing, should be increased to 12 hours per day, except in the case of busy crossings.

It must be remembered that the majority of the men referred to have a rate called the « B » rate-below which their wages cannot fall, and another called the « A » rate which is the wage actually paid, and varies according to the cost of living, *viz.*, 1 sh. per week for every change of 5 points.

The hearing occupied seven days, and in addition to the case presented by the railway companies and the Union, the Board heard the president of the Aberdeen Chamber of Commerce, who gave evidence on behalf of that body in support of the railway companies.

The decisions given by the majority of the Board may be summarised as follows :

I. — *Wages.*

That the advances given in June 1920 shall be withdrawn as follows. Any fall in wages occurring under the sliding scale agreement subsequent to the date of this Award shall be doubled until the advances given under the decision of June 1920 have been absorbed; that is to say, until the advances have been so absorbed the wages of each employee concerned shall be reduced by 2 sh. per week instead of 1 sh. per week for each fall of five points in the cost of living index number. In no case however shall wages be reduced below the « B » or standard rate. Special provision was made for certain signalmen whose classification had not been fixed.

II. — *Payment for night duty.*

The claim for alteration was said to not have been established.

III. — *Junior employees.*

a) The age at which a youth is to be regarded as an adult was raised from 18 tot 20 years.

b) A new scale for new entrants was adopted, and was to be applied to those already in the service and under 18 years of age. This varies from 16 sh. per week at 15 years or under to 35 sh. per week at 19 years of age.

c) Youths in the service between 18 and 20 years of age and receiving 53 sh. per week or over to be reduced to 50 sh. per week, and to be subject to a reduction according to fall in the cost of living on the basis of the Award for wages (I) until they reach the rate in accordance with *b*).

d) The raising of the adult age from 18 to 20 years not in itself to be held as a justification for re-grading as a « junior » position any post now graded as an « adult » position.

e) The railway companies to ascertain at the first possible moment after engagement whether the new entrant is likely to prove efficient so as to prevent, as far as possible, the discharge of such servant on reaching adult age.

IV. — *Hours of work.*

a) In cases where economy will accrue, arrangements are allowed for men to work up to 9 hours per day, any time after 8 hours being paid for at overtime rates.

b) The arrangements under which men work five long turns and one short one to be continued.

c) The eight hour day to continue, but a « spread over » up to ten hours per day may be put into operation in cases where men can be booked off and free from duty for the period in excess of the rostered (arranged) day. In addition where circumstances make it essential and economical the « spread over » may be extended to a maximum of twelve hours per day. This to apply to all grades (except drivers, firemen and guards) employed at such stations as shown in the statement presented to the board. Any disagreement as to this latter to be referred to a Committee consisting of two members chosen by the Scottish railway companies and two members chosen by the National Union of Railwaymen. If these do not agree the case to be referred to the chairman of the board or to the full board.

The decision generally was put into operation on 1 February 1922.

The above is the decision of the majority of the Board, but a minority report was made by the two members who were general managers of Scottish railways. In this they disagree with the findings of the main body of the Board, and call special attention to two points. These are that prior to standardisation of wages in Great Britain in August 1919 and January 1920, the Scottish railways paid wages on a lower basis than that paid in England and Wales to similar grades, and that the findings would only in a small manner relieve the Scottish railway companies of the enormous burden placed on them by the universal application of the eight hour day.

Subsequent to the above Award, several meetings have been held in England between the representatives of the railway companies and of the Unions. Finally, an agreement has been arrived at to make the Scottish award apply to the English railways, and for this to come into operation on 1 April 1922.

H. F.

[385. (09.2]

OBITUARY

F. HENNINGS,

Professor at the Zurich Polytechnic School;
Delegate of the Swiss Government
and Reporter to the eighth Session (Berne 1910) of the International Railway Congress.

We have learned with regret of the death of Mr. F. Hennings, who was a reporter on question IV (long railway tunnels; their construction, ventilation and working) at the 8th session (Berne 1910), where his treatise relating to the sub-Alpine tunnels was well received.

Born at Kiel on the 15 December 1838, Fritz Hennings obtained his degree as engineer in 1861 at the Zurich Technical High School, and entered into practical work in the construction of the Zurich-Zug-Lucerne railway.

After having assisted in the construction of Austrian and Swiss railways, he was for six years the right-hand man of R. Moser, the chief engineer of the North-East Swiss Railway, and was principally occupied in the construction of the Emmensberg tunnel near Schaffhousen; in preparing the report of the projected Splügen line, and of the Guyer-Zeller freak line, known as the « Oriental railway », and later on in the construction of the railway uniting Thusis with the Engadine by way of the Albula.

To all his colleagues and subordinates the name of Hennings remains that of an ideal man, both personally and in his work, a great constructor and advisor and a man of great human sympathy. In the Grisons especially he embodied all that was most important both in the development and construction of the railways in that district.

In the memoir of him in the *Schweizerische Bauzeitung*, Mr. G. Benerlin recalls the important works in which he took part, nearly all of which were connected with the construction of railways, especially mountain railways, on which his work and knowledge stand out pre-eminently.

The Executive Committee.

NEW BOOKS AND PUBLICATIONS

[385. (06.14 & 385. (04]

AMERICAN RAILWAY ASSOCIATION. — **Historical statement. Present activities.** — 15 August 1921. — Pamphlet (9 × 6 inches) of 134 pages with plate.

The « American Railway Association » is, as is well known, a recognised organization formed by the American companies for the purpose of examining all questions relating to the working of railways in general. The pamphlet, which it has just published, gives a report containing interesting details concerning its actual development and the results obtained from its investigations.

The report begins with an historical summary of the more important problems which co-operation between the various railway companies has solved, and which have had a great influence on the progress made by the United States Railways.

The Association commenced with conferences which were held at Louisville in 1872 on the subject of time tables. Its work was then entirely limited to settling the times of through passenger traffic. In 1883, *Standard times* were adopted which made relations between the different companies much easier by reducing to four the number of different times in use on the various railways of the Union. Up till then each railway company adopted the local time of its head quarters, and in consequence there were more than fifty times differing from one another by several minutes.

The improvement introduced took the Meridian of Greenwich as basis, and was arranged so that a difference of sixty minutes should occur between the different times. This principle was later extended to the time tables of the whole world.

Other questions of general interest were then gone into and the field gradually enlarged. The original *Time Table Meeting,* which became in 1875 *General Time Convention,* was changed in 1891 to its present name which was more suitable for the various subjects submitted for discussion to the numerous committees appointed by the Association.

In 1919, the « American Railway Association » joined up with ten other groups interested in railway questions and which dealt with special matters, amongst which were the « American Railway Master Mechanics' Association » the « Master Car Builder's Association » and the « Railway Signal Association », so that actually a vast organization under the same general management has been formed which is actively concerned in the working of all the railways. Its object is defined in article 2 of the rules, *viz.,* to try and obtain by advisory methods the standardization and co-ordination of the principles and processes that are applied in the construction, upkeep and working of the American railways.

The work is divided into seven sections, the titles of which represent their essential work and are as follows :

Division I : Operating;
Division II : Transportation;
Division III : Traffic;

Division IV : Engineering;
Division V : Mechanical;
Division VI : Purchases and stores;
Division VII : Freight claims.

In the pamphlet a special chapter is given to each section in which is a complete list of subjects on which a decision has been taken and technical specifications, rules and regulations which have resulted from them, a list of the questions that are now being investigated and the names of those members whose special knowlegde places them in any particular section. Each question or group of questions is entrusted for examination to a special committee appointed from the section to which it refers, and sometimes to a mixed committee formed of members of several sections. The total number of committees and sub-committees in a section may reach 56.

The examination of this summary shows the considerable development of the « American Railway Association ». It may be said that its activities touch everything that has to do directly or indirectly with railways; it studies and deals with all problems arising from their establishment, the construction of the lines and their equipment with safety apparatus and machinery of every kind, methods of working, construction of rolling stock, processes of manufacture, conditions of ordering material and the relations of the companies with the State, themselves and the public.

Valuable results have been obtained, especially as regards standardization, and as an example, we give the following figures taken from the chapter relating to Division V (Mechanical) which gives the number of spare parts necessary for some of the rolling stock fittings in 1882 and in 1921 :

	Number of kinds.	
	1882	1921
Axles.	56	5
Axle boxes	58	5
Couplings.	26	1
Brake blocks	20	1
Brake hangers	27	1

Amongst the mixed committees, special mention is given to the subject of fuel and the automatic train control. For the latter the delegates of the « American Railway Association » worked in collaboration with the « Interstate Commerce Commission», a Government organization to which the law allows a very large controlling power over railway companies. We know that in consequence of its researches, forty-nine companies have been requested to fix up on a certain portion of their lines, and within a period of two years, an automatic system for stopping trains.

The pamphlet gives at the end the rules of the Association and its inner regulations, also a plate showing, in diagrammatic form, the complete organization of the institution.

E. M.